

**Water Quality Monitoring in the Hungerford Brook and Black Creek
2018**

Total Phosphorus and Total Nitrogen in Two Tributaries of the Missisquoi River



**Franklin County Natural Resources Conservation District
with support from the
DEC LaRosa Partnership Program**

Prepared for the
Vermont Department of Environmental Conservation

by

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4 March 2019

Franklin County Natural Resources Conservation District

The Franklin County Conservation District (the District) is one of 14 conservation districts throughout Vermont. The District's mission is to promote land use that supports human livelihoods and sustains ecosystems in Franklin County, VT. The Conservation District empowers and convenes landowners and land-users to prioritize and address natural resource concerns and recognizes water quality and the continuance of our land-based economy as key concerns for Franklin County today.

Cover Photo. A view of tributary #4 to the Hungerford Brook along the Missisquoi Rail Trail in Swanton, VT on April 18, 2018. In the distance is Rocky Ridge, the topographic boundary between the Hungerford Brook and the Black Creek subwatersheds.

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Acknowledgments

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1.0 Introduction

Lake Champlain is an integral part of life for those who live nearby or come to visit – it provides a significant source of drinking water, opportunities for a myriad of recreational activities, habitat for plants and animals, a water source for energy, industry and agriculture, a place to dispose of treated wastewater, beautiful views, and historical significance as the home of the oldest known fossil reef in the world (Gerhardt 2018, Lake Champlain Basin Program 2018, Lake Champlain Land Trust). Water quality in Lake Champlain and its tributaries have been on the decline in recent history due to excessive nutrient and sediment loading, resulting in eutrophic conditions and the common occurrence of cyanobacteria blooms in several segments of Lake Champlain, including the Missisquoi Bay (Gerhardt 2018). To address these issues, the Vermont Department of Environmental Conservation (VDEC) first began developing phosphorus Total Maximum Daily Loads (TMDLs) for Lake Champlain in the late 1990s (Environmental Protection Agency 2016). The most up to date version was approved by the EPA in 2016, and since then there has been a strong effort to fund and implement projects and practices that reduce phosphorus loading in surface waters across the state (Environmental Protection Agency 2016, Lake Champlain Basin Program 2018). One segment of Lake Champlain addressed by the TMDL and in the greatest need of these efforts is the Missisquoi Bay Basin (Gerhardt 2018). This northeastern-most corner of the lake receives water draining from the majority of Franklin County, part of Orleans County, and part of the Montérégie region of Quebec (Bates 2016). The main rivers which feed the Bay are the Pike, Rock, and Missisquoi Rivers (Environmental Protection Agency 2016). Many of the tributaries to these rivers are listed as impaired or stressed due to nutrient and/or sediment pollution in the most recent VDEC Missisquoi River Watershed Water Quality and Aquatic Habitat Assessment Report (Vermont Department of Environmental Conservation 2015).

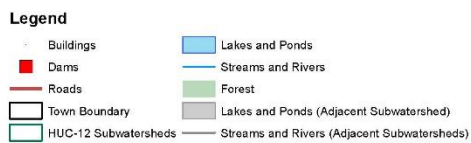
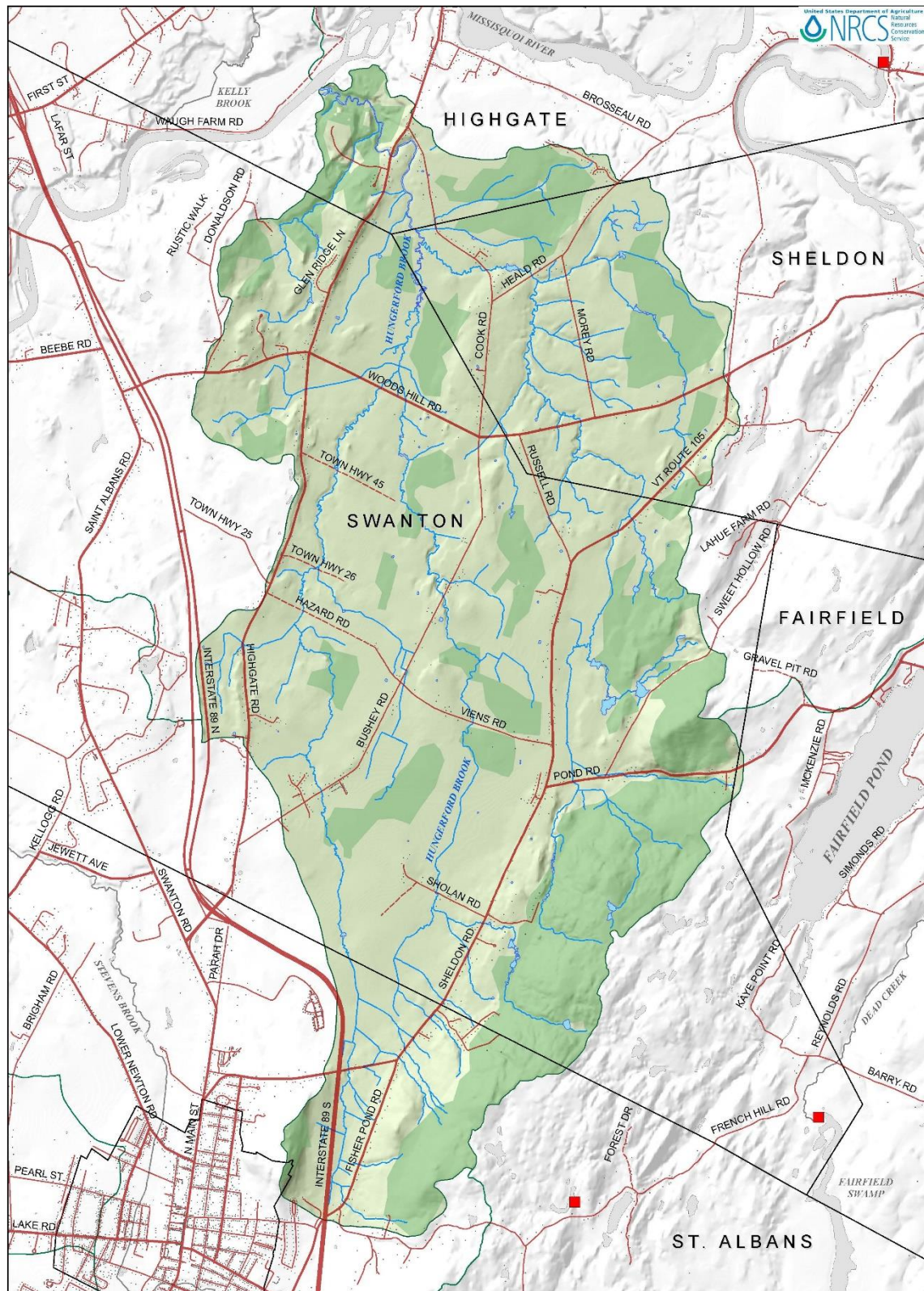
2.0 Study Goals

The Missisquoi River Basin Association has been monitoring total phosphorus, total nitrogen, and turbidity of the Missisquoi River and some of its tributaries since 2005 (Vermont Department of Environmental Conservation 2015). This long-term monitoring effort, along with several studies, have shown high phosphorus levels in the Hungerford Brook and Black Creek, indicating that these tributaries are likely significant sources of nutrient and sediment pollution to the Missisquoi River and thus the Missisquoi Bay (Gerhardt 2018). In 2018, the Franklin County Natural Resources Conservation District (the District) began monitoring sites previously monitored by the MRBA and added additional sites recommended in previous reports on water quality data in these subwatersheds. The goal of the District was to build on the monitoring efforts of our partners to (1) further identify spatial patterns in water quality conditions, (2) pinpoint nutrient and sediment sources, (3) identify critical areas to focus conservation efforts of the District and its local partners, and (4) inform future monitoring efforts. This spatial trend monitoring report details 2018 water quality at 24 sites in the Hungerford Brook and Black Creek watersheds, sampled bi-weekly from April to November.

3.0 Description of Watersheds

Hungerford Brook

The Hungerford Brook (Waterbody ID VT06-03) drains 12,535 acres in the Missisquoi Bay Basin and accounts for 2.9% of the USA portion of the basin. According to the USGS the Hungerford Brook is categorized as a subwatershed and has been assigned a 12-digit Hydrologic Unit Code (HUC-12): 041504070602. The Hungerford Brook and its tributaries drain areas in the towns of Highgate, Sheldon, Swanton, and St. Albans in Franklin County, Vermont. Land use in the Hungerford Brook is 6% urban, 44% agricultural, and 34% forested (2016 Missisquoi Bay Tactical Basin Plan). In Stone Environmental's 2011 study, *Identification of Critical Source Areas of Phosphorus Within the Vermont Sector of the Missisquoi Bay Basin*, it is estimated that the annual phosphorus load to the Missisquoi Bay from the Hungerford Brook is 2,776 kg (3.67% of the total P load). In contrast to much of eastern Franklin County, the Hungerford Brook subwatershed is relatively flat although most major branches of the brook have their headwaters in the forested hills of Rocky Ridge in the southeastern portion of the subwatershed. This study focuses on the mainstem of the Hungerford Brook and two of its tributaries, tributary #4 in the eastern part of the subwatershed and tributary #6 in the center of the subwatershed. The subwatershed's soils are primarily silt and clay loams. The bedrock geology of the Hungerford Brook is primarily composed of Cambrian to Middle Ordovician black, calcareous slate, schist and phyllite. The branches of the Hungerford Brook generally flow south to north with the highest point in the subwatershed located along the southeastern portion of the watershed along Rocky Ridge at 1,160 ft. and the lowest point at the confluence of the Hungerford Brook and the Missisquoi River at 120 ft.



0 0.7 1.4 Miles

Hungerford Brook

HUC-12: 041504070602

Acres: 12,535

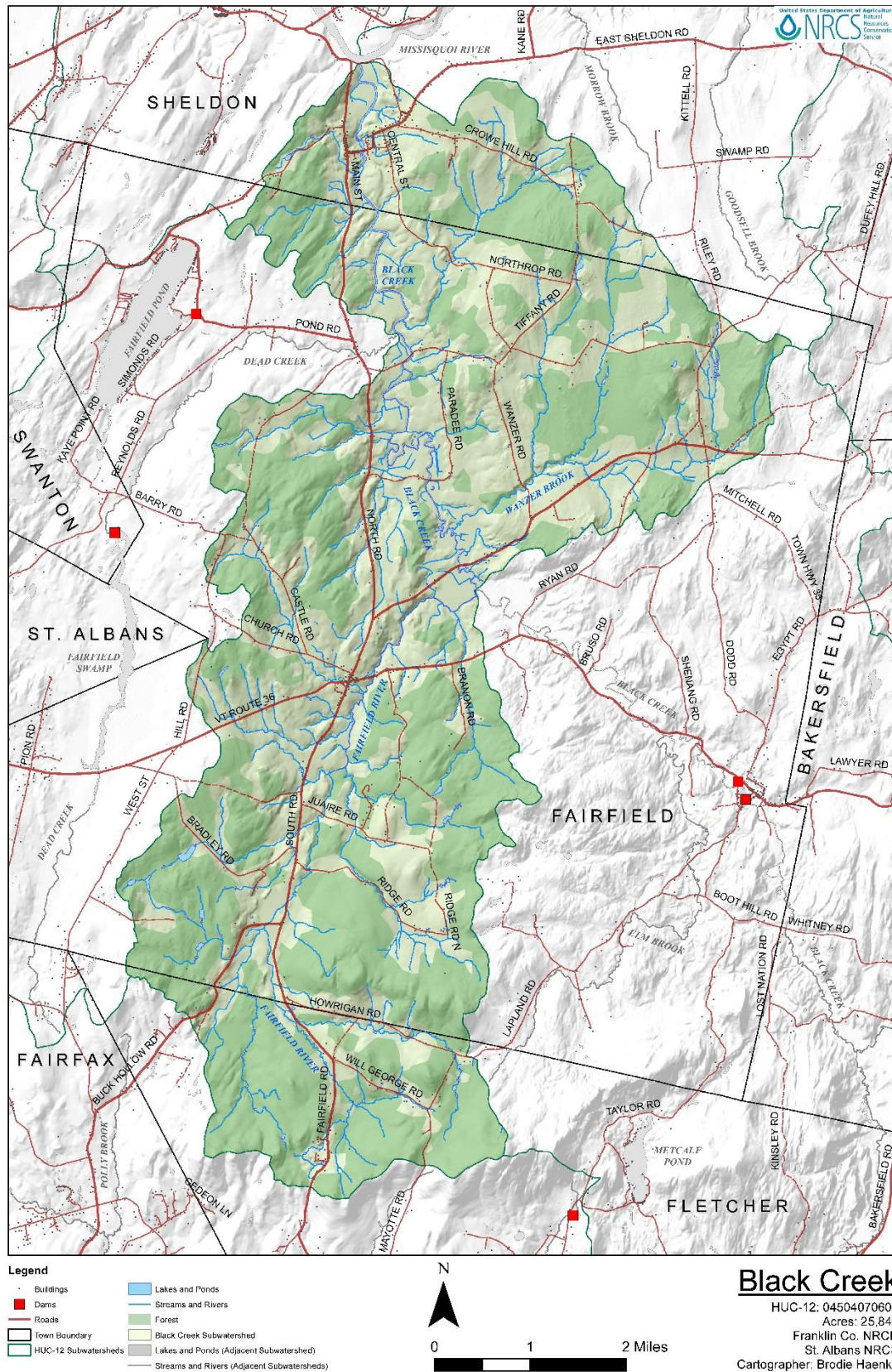
Franklin Co. NRCD

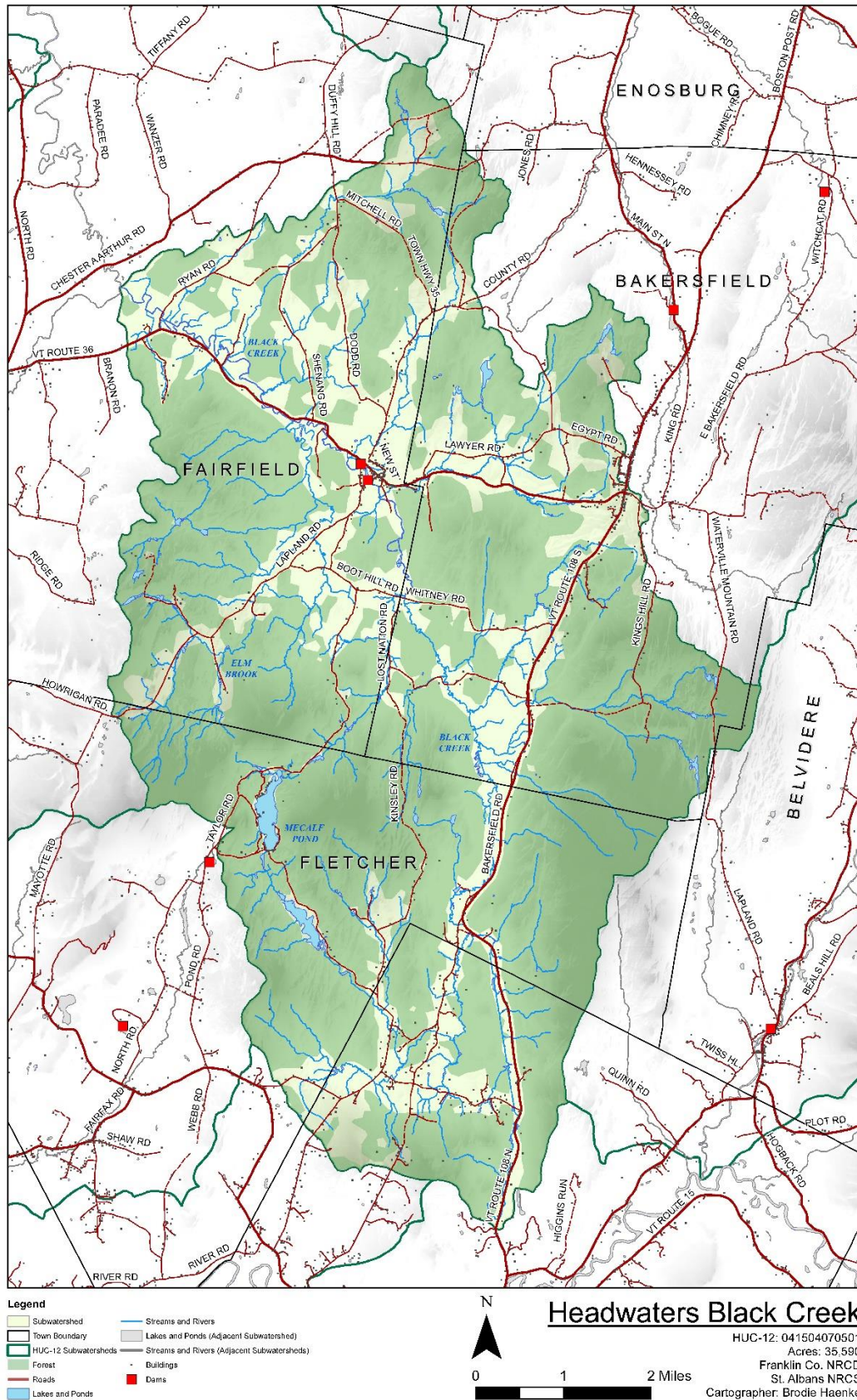
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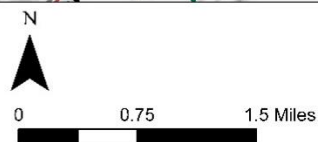
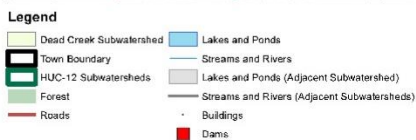
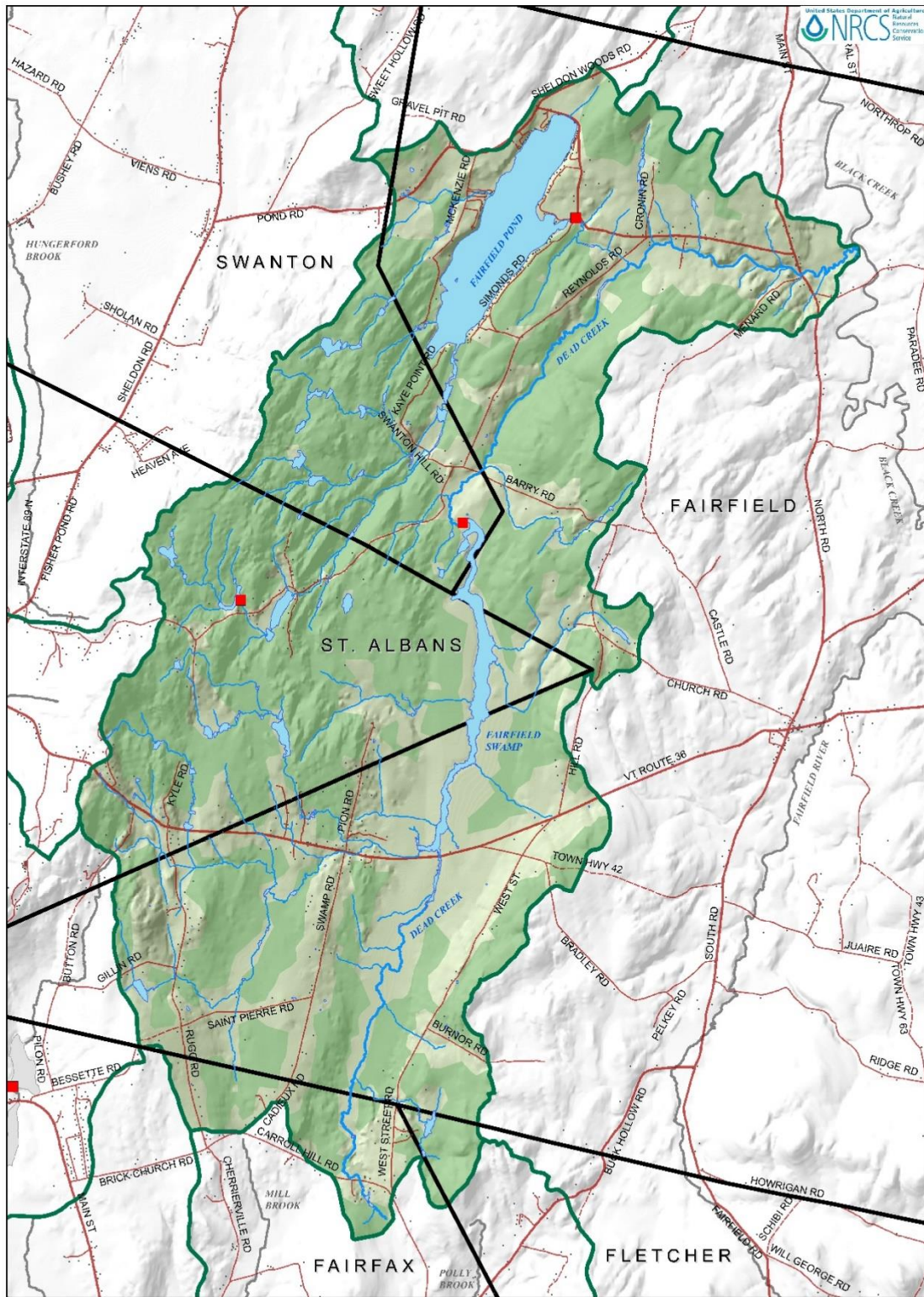
Cartographer: Brodie Haenke

Black Creek

The Black Creek (Waterbody ID VT06-05) drains 76,838 acres in the Missisquoi Bay Basin and accounts for 17.2% of the USA portion of the basin. A relatively large drainage basin, the Black Creek includes three HUC-12 subwatersheds: Black Creek (041504070503), Headwaters Black Creek (041504070501), and Dead Creek (041504070502). The Black Creek drains areas in the towns of Bakersfield, Fairfield, Fairfax, Sheldon, St. Albans, and Swanton. Land use in the Black Creek subwatersheds are 4% urban, 21% agricultural, and 63% forested (2016 Missisquoi Tactical Basin Plan). It is estimated that the annual phosphorus load to the Missisquoi Bay from the Black Creek is 5,481 kg (7.25%), Headwaters Black Creek is 4,463 kg (5.90%), and Dead Creek is 2,050 kg (2.71%) (Stone Environmental, 2011). In contrast to the Hungerford Brook, the topography of the Black Creek basin includes several ridges and rolling hills which act as hydrologic boundaries that further subdivide the watershed into various tributaries including the Dead Creek, Fairfield River, Elm Brook, Paige Brook and Wanzer Brook. The soils of this watershed are primarily silt loams and fine sandy loams. The headwaters of the Black Creek lie in the forested hills of Bakersfield, Fletcher, and Cambridge where the highest point of the watershed can be found atop Fletcher Mountain at 2,110 ft. The lowest point in the watershed lies at the confluence of the Black Creek with the Missisquoi River north of the Sheldon town center at 335 ft.







Dead Creek

HUC-12: 041504070503
 Acres: 15,404
 Franklin Co. NRCD
 St. Albans NRCS
 Cartographer: Brodie Haenke

4.0 Methods

In 2018, the Franklin County Natural Resources Conservation District measured total phosphorus and total nitrogen concentrations at twenty-four sites on fifteen dates throughout the Hungerford Brook and Black Creek subwatersheds. Water quality samples were collected by trained District staff, ECO AmeriCorps members, and volunteers operating under a VTDEC and EPA approved Quality Assurance Project Plan (QAPP).

Samples were collected once every two weeks on a pre-determined schedule beginning on April 18 and ending on November 14. Two pre-determined sampling events did not occur throughout the sampling collection period on July 11 and November 28 due to District schedule conflicts and hazardous weather conditions, respectively.

Total phosphorus samples measure the concentration of all forms of phosphorus within the water column, including dissolved phosphorus, phosphorus adhered to suspended sediment, and phosphorus in organic matter. Total nitrogen samples measure the concentration of all forms of nitrogen in the water column including nitrogen gas (N₂), nitrite (NO₂), nitrate (NO₃), ammonia (NH₄), and particulate nitrogen (N).

For this report, the District analyzed the data collected in 2018 within the Hungerford Brook and Black Creek subwatersheds using the spatial trend template created by Kristen Underwood for the DEC LaRosa Partnership Program participants. Samples collected by the District were transported to the Vermont Agriculture and Environmental Laboratory in Burlington, Vermont for analysis. Water quality data was then downloaded from the DEC's volunteer monitoring portal (<https://anrweb.vt.gov/DEC/DEC/VolunteerMonitoring.aspx>). To ensure that water samples were collected without contamination and in a repeatable manner quality assurance data was analyzed to pin point errors and outliers in the data.

Stream discharge data for the Missisquoi River in East Berkshire, VT was downloaded from the US Geologic Survey's WaterWatch web portal for use in approximating the hydrologic conditions of the Black Creek. Stream discharge data for the Hungerford Brook was supplied by Vermont EPSCOR. Precipitation data for the Hungerford Brook was also provided by Vermont EPSCoR.

The US Geologic Survey's StreamStats application was used to delineate the watershed drained by each sampling site which were then downloaded into shapefiles and mapped in ArcGIS 10.

All graphs created by the District for this report were created in Microsoft Excel and all maps were created in ArcGIS 10.

5.0 Results and Discussion

5.1 Quality Assurance

All water samples collected by the District during the sampling period were collected in accordance with the Quality Assurance Project Plan (QAPP), apart from the inconsistencies mentioned below.

During the development of this program, the District and our partners initially identified 26 sites in the Hungerford Brook and Black Creek subwatersheds and scheduled 17 bi-weekly sampling dates between April 18 and November 28. Due to budgetary concerns, the District removed two sites (Dead Creek – Barry Road, Black Creek – Paradee Road) from the program after the first two sampling dates. This change in total monitoring sites changed our total anticipated water samples collected for each parameter in 2018 from 442 to 412. At the end of our sample collection period, 327 valid samples had been collected for each parameter.

Sampling did not occur on two scheduled sampling dates due to a scheduling conflict on one occasion and hazardous weather on the other, resulting in 52 less samples for each parameter. This summer, Franklin County experienced a drought which resulted in 31 fewer samples for each parameter due to no flow conditions at several sites. On 7/25/2018 the sample collected at the Woods Hill Rd. Bridge site was taken during no-flow conditions (standing water) and was not taken in accordance with the QAPP, resulting in one fewer valid sample for each parameter. On 10/3/2018 at the Fairfield River – Juair Rd. site there was a miscommunication and a volunteer sampler did not go out to collect the samples, resulting in one fewer sample for each parameter.

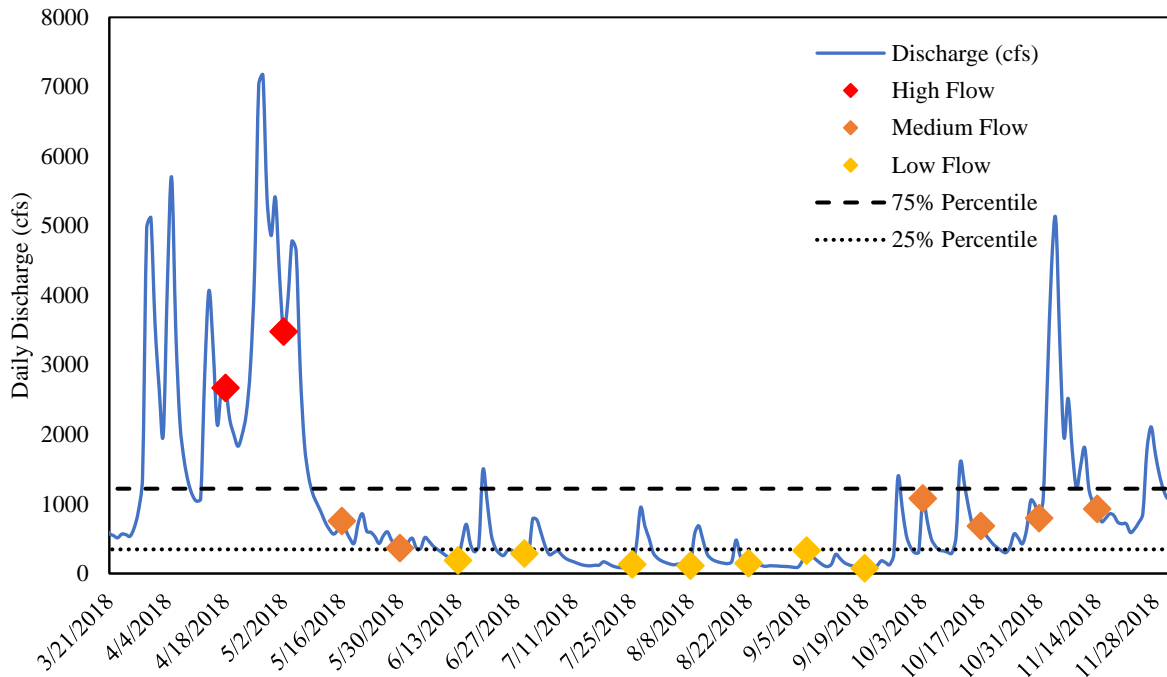
In total, 14 total phosphorus (TP) field duplicates and 14 total nitrogen (TN) field duplicates were collected at various sites during the sampling period. Field duplicates were collected in a manner accordant with the QAPP. Given that 327 samples were collected for each parameter, the percent of field duplicates collected relative to the amount of samples collected for each parameter is 4.3%. This is well under the 10% specified in the QAPP. The lower amount of field duplicates collected was greatly impacted by the drought we experienced this summer in Franklin County, as can be seen in the dates which duplicates were collected in the chart below. The mean relative percent difference (RPD) for all TP duplicates is 11%. The mean RPD for all TN duplicates is 7%. These values are well within the estimated precision for field duplicates specified for each parameter in the QAPP (TP \leq 30%, TN \leq 20%). On a few specific occasions the RPD exceeded the limits specified in the QAPP. On October 3, 2018 at Wilson Road the TP RPD was 33%, on October 17, 2018 at Lost Nation Rd. the TP RPD was 36%, and on May 31, 2018 at Paige Brook – Rail Trail the TN RPD was 52%. No field blanks were collected during the sampling period. In general, the low mean RPD between field duplicates and samples indicate that samples were collected in a repeatable manner.

5.2 Stream Flow

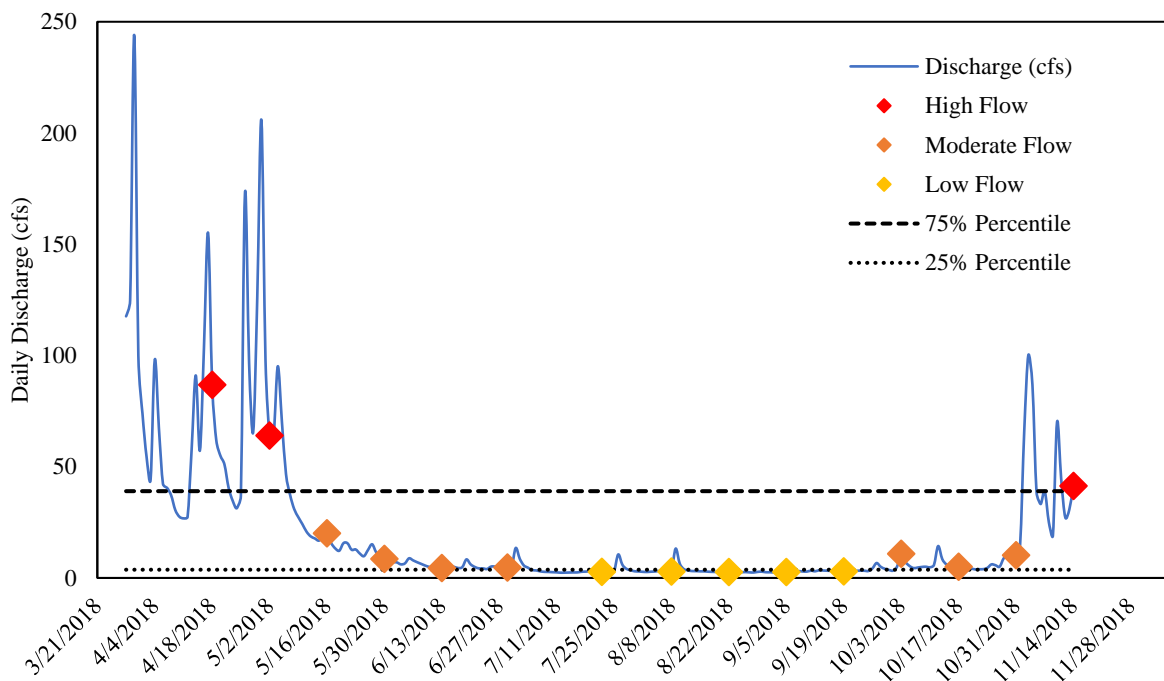
Stream flow, or discharge, measures the volume of water passing through a given location per unit time. The discharge of a stream or river can be calculated by multiplying the cross-sectional area of the stream by water velocity. Stream flow is extremely dynamic and in constant flux due to temporal changes in season, precipitation, and temperature. Stream flow has a significant influence on water quality, particularly as it relates to the transportation of sediment and nutrients in streams and rivers. The relationship between stream flow and the concentrations of soluble and suspended nutrients in streams and rivers is very complex and is a continued topic of study by researchers in New England and in the Lake Champlain Basin (Vaughn et al., 2017). During high flow conditions, such as snow melt or precipitation events, streams typically transport more nutrients and sediment than during low flow conditions. At the same time, greater volumes of water present in streams during high flow events dilute the concentrations of soluble and suspended nutrients in the water column. Quantifying the dynamic and episodic relationship between discharge and nutrient concentrations in streams is integral to understanding nutrient transport pathways and identifying critical source areas in watersheds, like the Missisquoi Bay Basin, that have EPA mandated nutrient export budgets (Evans and Davies, 1998).

To categorize the hydrologic conditions of the Hungerford Brook and Black Creek watersheds during each of our sampling dates, the District used daily stream flows measured from two stream gages in the Missisquoi Bay Basin. For the Hungerford Brook, the District received discharge values from Vermont EPSCoR's stream gage along the Hungerford Brook at Highgate Road in Highgate, VT (Table 1, Graph 2). To estimate flow conditions in the Black Creek watershed, the District used daily discharge data from USGS Station 04293500 along the Missisquoi River near East Berkshire, VT as there is currently no stream gage along the Black Creek (Table 1, Graph 1). As is typical of northern New England, stream flow varied considerably throughout 2018 and the District's fifteen sampling events between April and November only captured a limited subset of flow conditions. Despite our limited sampling frequency and pre-determined sampling schedule, the District's 2018 monitoring program did collect water samples during high, moderate, and low flow conditions in both watersheds. It is important to note that in the summer of 2018, Northwest Vermont and parts of Franklin County experienced a drought. During this drought, District staff and volunteers were unable to collect water samples at several monitoring sites along the Hungerford Brook and its tributaries and Wanzer Brook due to no-flow conditions.

Flow conditions varied between each stream gage on the same dates. In both the Hungerford Brook and Missisquoi River, samples were collected during high flow conditions during the first two sampling dates on April 18 and May 2, 2018. The Hungerford Brook sustained moderate flow conditions for the subsequent four sampling dates between May 16 and June 27, while the Missisquoi River in East Berkshire only sustained moderate flows for the subsequent two sampling dates on May 16 and May 30, 2018. Although moderate and high flow conditions continued to occur intermittently along the Missisquoi River in East Berkshire throughout the summer of 2018, samples were only collected at low flow conditions between June 13 and September 19, 2018. In the Hungerford Brook, moderate flow conditions occurred



Graph 1: Daily discharge in cubic feet per second at the USGS stream gage (station 04293500) along the Missisquoi River in Berkshire, VT between March 21, 2018 and November 28, 2018. This stream gage is used to approximate flow conditions in the Black Creek watershed. The 25% (347 cfs) and 75% (1,220 cfs) percentile values are taken from a previous report written on water quality data in these tributaries (Gerhardt 2018).



Graph 2: Daily discharge in cubic feet per second from the Vermont EPSCoR stream gage along the Hungerford Brook at Highgate Road in Highgate, VT. The 25% (3.7 cfs) and 75% (29 cfs) percentile values are taken from the records of the USGS stream gage (station 04293900) along the Hungerford Brook at Highgate Road in Highgate, VT between September 11, 2009 and October 6, 2014.

Date	Missisquoi River, East Berkshire		Hungerford Brook, Highgate	
	Discharge (cfs)	Flow Category	Discharge (cfs)	Flow Category
4/18/2018	2670	High	86.8	High
5/2/2018	3480	High	64.0	High
5/16/2018	754	Moderate	20.1	Moderate
5/30/2018	365	Moderate	8.6	Moderate
6/13/2018	189	Low	4.5	Moderate
6/29/2018	288	Low	4.6	Moderate
7/25/2018	131	Low	3.1	Low
8/8/2018	112	Low	2.9	Low
8/22/2018	148	Low	2.7	Low
9/5/2018	328	Low	2.7	Low
9/19/2018	76.2	Low	2.9	Low
10/3/2018	1080	Moderate	10.9	Moderate
10/17/2018	683	Moderate	5.0	Moderate
10/31/2018	795	Moderate	10.2	Moderate
11/14/2018	930	Medium	41.4	High

Table 1: Daily discharge data and stream flow condition at the USGS stream gage along the Missisquoi River in East Berkshire, VT (station 04293500) and Vermont EPSCoR's stream gage along the Hungerford Brook at Highgate Road in Highgate, VT on each 2018 sampling date.

intermittently throughout the summer of 2018, but samples were only collected during low flow conditions between July 25 and September 19. Both stream gages recorded moderate flow conditions on October 3 and each sampling date that followed were collected at either moderate or high flow conditions. In the Hungerford Brook, a third high flow condition sample was collected on November 14, 2018 while samples in the Black Creek were only collected while the Missisquoi River was at moderate flow conditions for the remainder of the sample collection period.

5.3 Meteorological Conditions

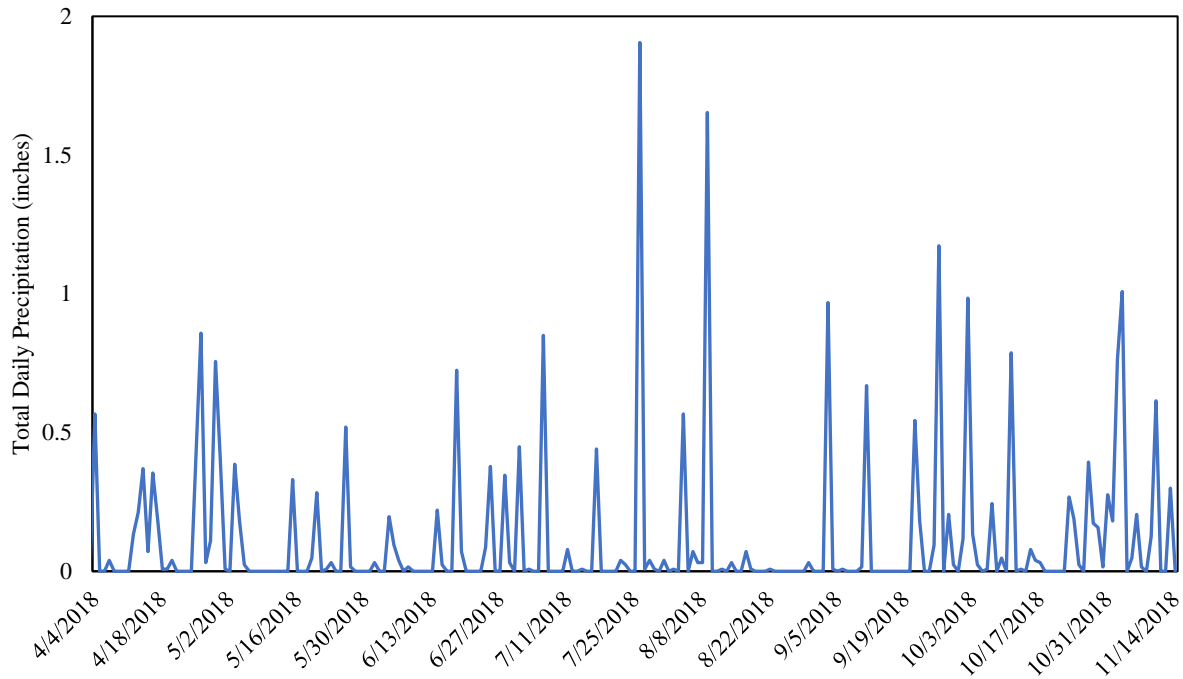
Precipitation and temperature have a significant impact on the hydraulic condition of a watershed and on the subsequent mobilization of nutrients and sediment in streams. To characterize the meteorological conditions of the Hungerford Brook and Black Creek subwatersheds, the District requested precipitation and temperature data collected by Vermont EPSCoR at their site in the Hungerford Brook watershed. As stated above, northwestern Vermont experienced drought conditions in the late summer of 2018 which resulted in low flow conditions for a majority of the summer and intermittent no-flow conditions at several sites in the Hungerford Brook watershed and along the Wanzer Brook and Fairfield River in the Black Creek watershed between late July and early October.

Waterbody	Site Name	7/25/2018	8/8/2018	8/22/2018	9/5/2018	9/19/2018	10/3/2018
Hungerford Brook	Route 207	Low	Low	Low	Low	Low	Moderate
	Woods Hill Rd. Bridge	No Flow	Low	Low	Low	Low	Moderate
	Hazard Rd.	No Flow	Low	Low	No Flow	Low	Moderate
	Missisquoi Rail Trail	No Flow	Low	Low	No Flow	Low	Moderate
Hungerford Brook Tributary #6	Woods Hill Rd. Culvert	Low	Low	Low	Low	No Flow	Moderate
	Viens Rd.	No Flow	No Flow	Low	No Flow	No Flow	No Flow
	Sholan Rd.	No Flow	No Flow	Low	No Flow	No Flow	No Flow
Hungerford Brook Tributary #4	Heald Rd. (East)	No Flow	Low	No Flow	Low	No Flow	Moderate
	Heald Rd. (West)	No Flow	Low	No Flow	Low	No Flow	Moderate
	Sheldon Rd.	Low	Low	No Flow	Low	No Flow	Moderate
	Missisquoi Rail Trail	Low	Low	No Flow	Low	No Flow	Moderate
Wanzer Brook	Wanzer Road	No Flow	No Flow	No Flow	No Flow	No Flow	Moderate
Fairfield River	Rail Trail	Low	Low	Low	Low	No Flow	Moderate
	Juaire Road	Low	Low	Low	Low	Low	Moderate

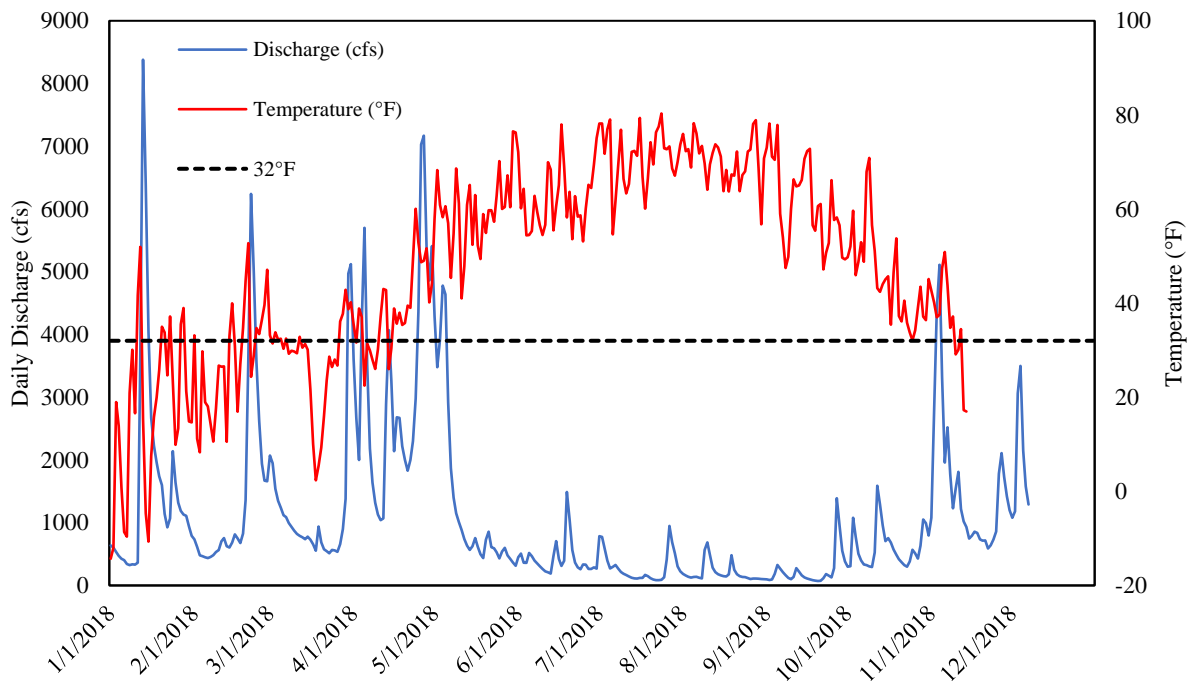
Table 2: Hydrologic conditions along all tributaries included in this monitoring program that experienced no-flow conditions between July 25 and October 3, 2018.

Date	Daily Precipitation (inches) on Days Prior to Sampling					
	4 Days	3 Days	2 Days	1 Day	Day of Sampling	Cumulative
4/18/2018	0.37	0.07	0.35	0.19	0.01	0.99
5/2/2018	0.11	0.76	0.40	0.01	0.00	1.28
5/16/2018	0.00	0.00	0.00	0.33	0.00	0.33
5/30/2018	0.52	0.02	0.00	0.00	0.00	0.54
6/13/2018	0.00	0.00	0.00	0.00	0.00	0.00
6/29/2018	0.38	0.00	0.00	0.35	0.03	0.76
7/25/2018	0.00	0.04	0.02	0.00	0.00	0.06
8/8/2018	0.57	0.00	0.07	0.03	0.03	0.70
8/22/2018	0.01	0.00	0.00	0.00	0.01	0.02
9/5/2018	0.00	0.00	0.97	0.01	0.00	0.98
9/19/2018	0.00	0.00	0.00	0.00	0.00	0.00
10/3/2018	0.02	0.00	0.12	0.98	0.13	1.26
10/17/2018	0.01	0.00	0.08	0.04	0.03	0.16
10/31/2018	0.39	0.17	0.16	0.02	0.28	1.02
11/14/2018	0.61	0.00	0.00	0.30	0.00	0.91

Table 3: Daily precipitation in inches on each sampling date and the 4 days prior as recorded at Vermont EPSCoR's Hungerford Brook station in Highgate, VT. Values for "Day of Sampling" reflects the total precipitation recorded on that date which may have occurred after all water samples were collected.



Graph 3: Recorded daily precipitation values in inches at Vermont EPSCoR's Hungerford Brook station in Highgate, VT throughout the 2018 sample collection period (April 4 to November 14, 2018).



Graph 4: Recorded temperature in Fahrenheit recorded at Vermont EPSCoR's Hungerford Brook station in Highgate, VT and daily discharge at the USGS stream gage along the Missisquoi River in East Berkshire, VT (station 04293500) as available during 2018. Note the sharp increases in discharge during the first instances of above-freezing temperature in the beginning of the year, indicative of snow melt events.



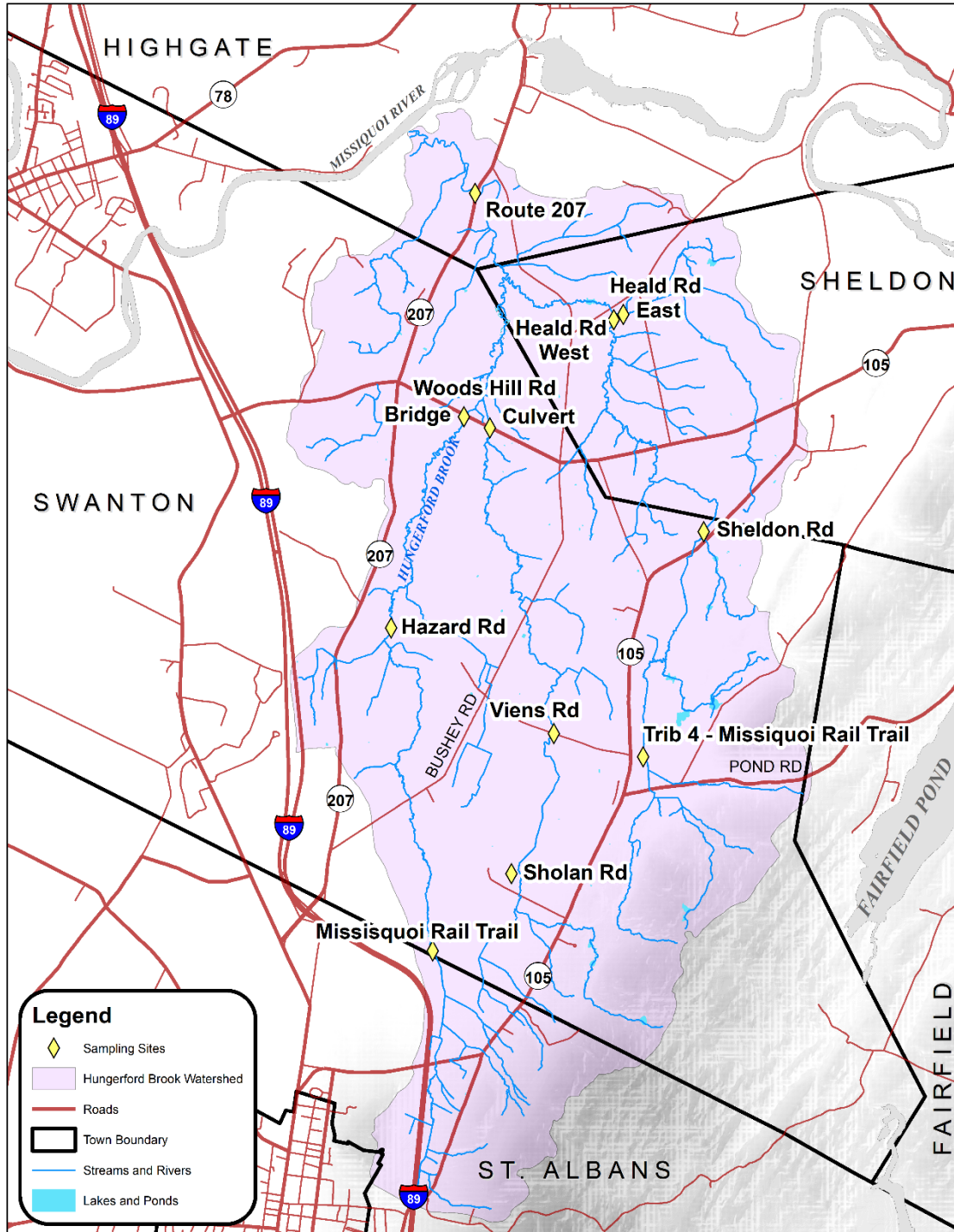
Picture 2: Taken April 18, 2018. Upstream of the sampling site at Viens Road along tributary #6 of the Hungerford Brook. This site is characterized by an excellent woody riparian buffer and shallow bank slopes.

5.4 Hungerford Brook

The District collected water quality samples at eleven sites within the Hungerford Brook subwatershed in 2018. This includes five sites that were previously monitored by the Missisquoi River Basin Association and six sites that were added in 2018. Two of these sites, Heald Road (East) and Heald Road (West) were specifically recommended in a previous report on water quality in this subwatershed (Gerhardt 2018). The addition of new sites further upstream of sites previously monitored in the Hungerford Brook and its tributaries has improved our understanding of potential source areas of phosphorus and nitrogen within the Hungerford Brook.

In 2018, mean total phosphorus concentrations were typically very high to moderate throughout the Hungerford Brook subwatershed. Along the mainstem, mean total phosphorus concentrations were greatest at the Woods Hill Road Bridge site and considerably lower at the two upstream sites. Mean total phosphorus concentrations were high or very high at all sites along tributary #4 but were greatest at the upstream most site along the Missisquoi Rail Trail and at the Heald Road (East) site. Mean total phosphorus concentrations were relatively lower along tributary #6 in comparison, with the greatest concentrations at the downstream most site at the Woods Hill Road Culvert.

Hungerford Brook



HUC-12: 041504070602
Acres: 12,535



Franklin Co. NRC, St. Albans NRCS
Cartographer: Liza Lemieux & Brodie Haenke

During high flow conditions, total phosphorus concentrations generally increased between upstream and downstream sites. Along the mainstem, total phosphorus concentrations increased most dramatically between the Woods Hill Road Bridge and Route 207 sites and between the Hazard Road and Woods Hill Road Bridge sites. Along Tributary #4, total phosphorus concentrations were typically greatest at the Heald Road (East) site, with increases greatest between Sheldon Road and Heald Road (West). Along Tributary #6, total phosphorus increases were present between upstream and downstream sites, but more variable on each sampling date.

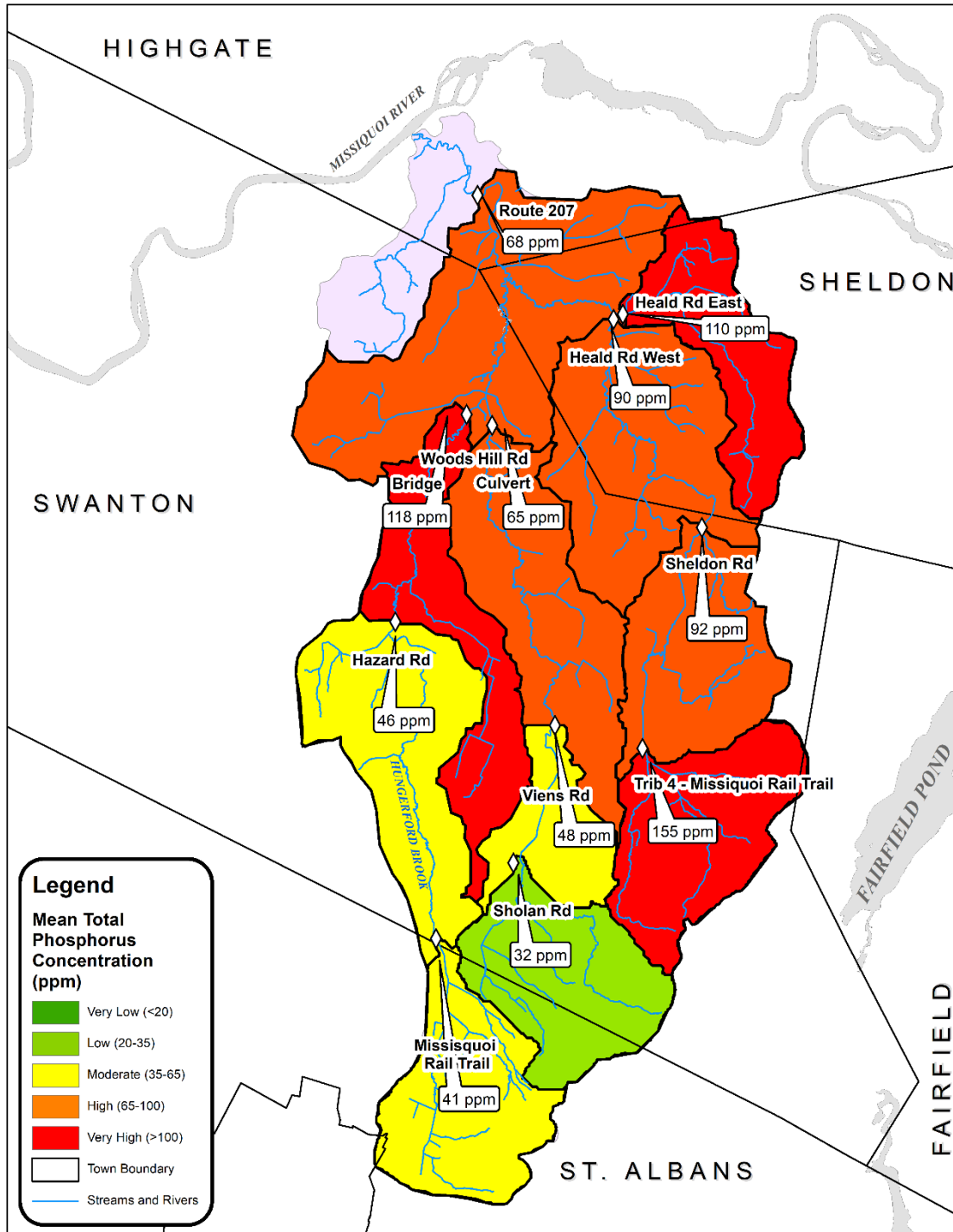
During moderate and low flow conditions, total phosphorus concentrations were more variable between upstream and downstream sites and drought conditions throughout the summer (July 25 to September 19) prevented the collection of samples at several sites throughout the watershed (GRAPH #). Despite the limited dataset, consistent patterns or “profiles” are present during six low to moderate flow events in the early summer and fall when flow was present along the three major reaches of the Hungerford Brook (GRAPH #). During these low and moderate flows, total phosphorus concentrations increase most dramatically between Hazard Road and the Woods Hill Road Bridge. Along tributary #4, total phosphorus concentrations are consistently highest at the Heald Road (East) site and the upstream most site along the Missisquoi Rail Trail, lowest at the Sheldon Road site, and moderately increase between Sheldon Road and Heald Road (West).

These results suggest there are significant phosphorus sources between Hazard Road and Woods Hill Road Bridge along the mainstem, and upstream of the Missisquoi Rail Trail and Heald Road (East) sites along tributary #4.



Picture 3: Taken May 30, 2018. Upstream of the Heald Road (West) site along tributary #4 of the Hungerford Brook. This site is characterized by unstable stream banks.

Hungerford Brook



HUC-12: 041504070602
Acres: 12,535

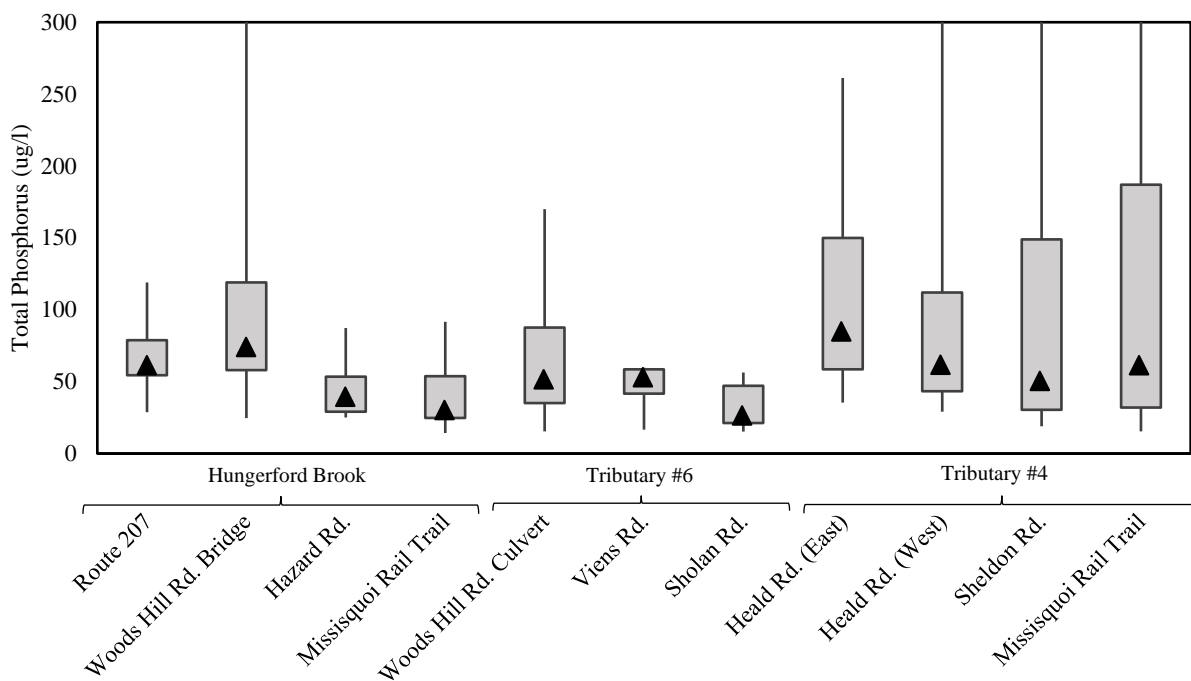


0 1 2 Miles

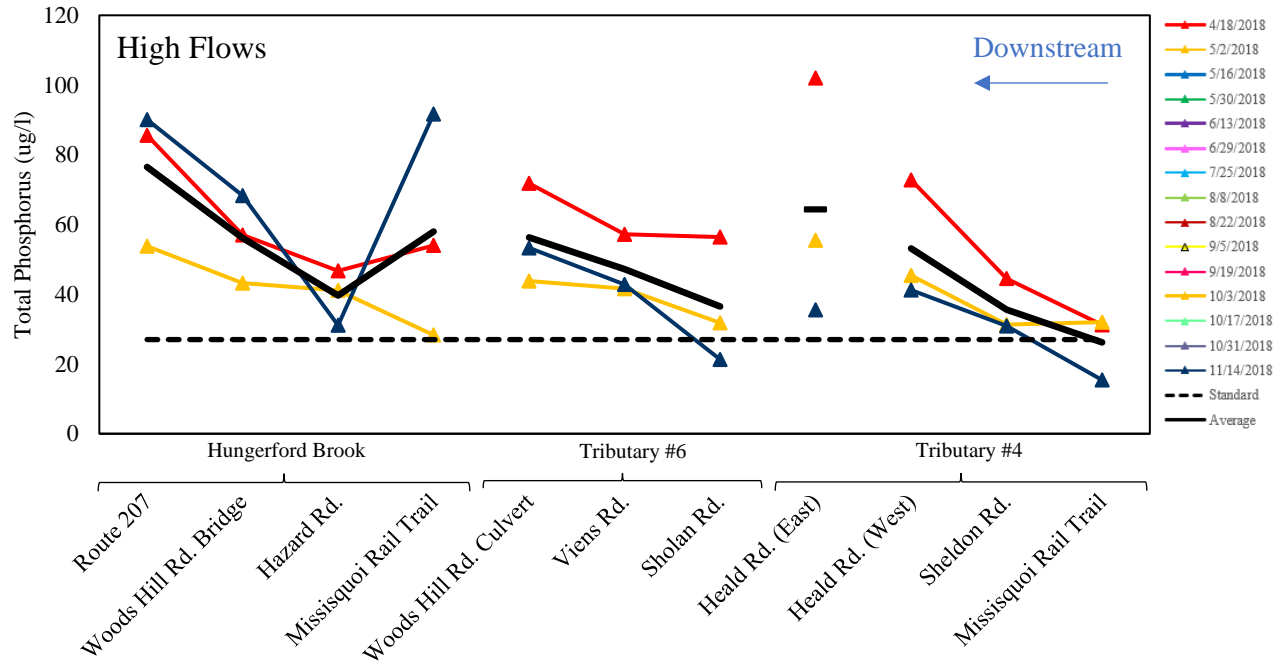
Franklin Co. NRCD, St. Albans NRCS
Cartographer: Liza Lemieux & Brodie Haenke

Site Name	# of Dates Sampled	Median (ug/l TP)	Mean (ug/l TP)	Range (ug/l TP)
Hungerford Brook - Route 207	15	63.1	68.4	28.8-119
Hungerford Brook - Woods Hill Rd. Bridge	13	75.7	118.1	24.7-597.6
Hungerford Brook - Hazard Rd.	11	41.1	46.4	25.1-87.3
Hungerford Brook - Missisquoi Rail Trail	11	31.9	40.6	14.3-91.7
Hungerford Brook Tributary 6 - Woods Hill Rd. Culvert	15	53.3	65.2	15.4-170
Hungerford Brook Tributary 6 - Viens Rd.	9	54.7	48.0	16.7-59.7
Hungerford Brook Tributary 6 - Missisquoi Rail Trail	9	28.1	32.3	15.3-56.4
Hungerford Brook Tributary 4 - Heald Rd. (East)	14	86.5	110.1	35.5-261.3
Hungerford Brook Tributary 4 - Heald Rd. (West)	13	63.4	90.1	29.1-306
Hungerford Brook Tributary 4 - Sheldon Rd.	14	52.2	92.3	19-346.8
Hungerford Brook Tributary 4 - Missisquoi Rail Trail	15	63	154.6	15.4-630

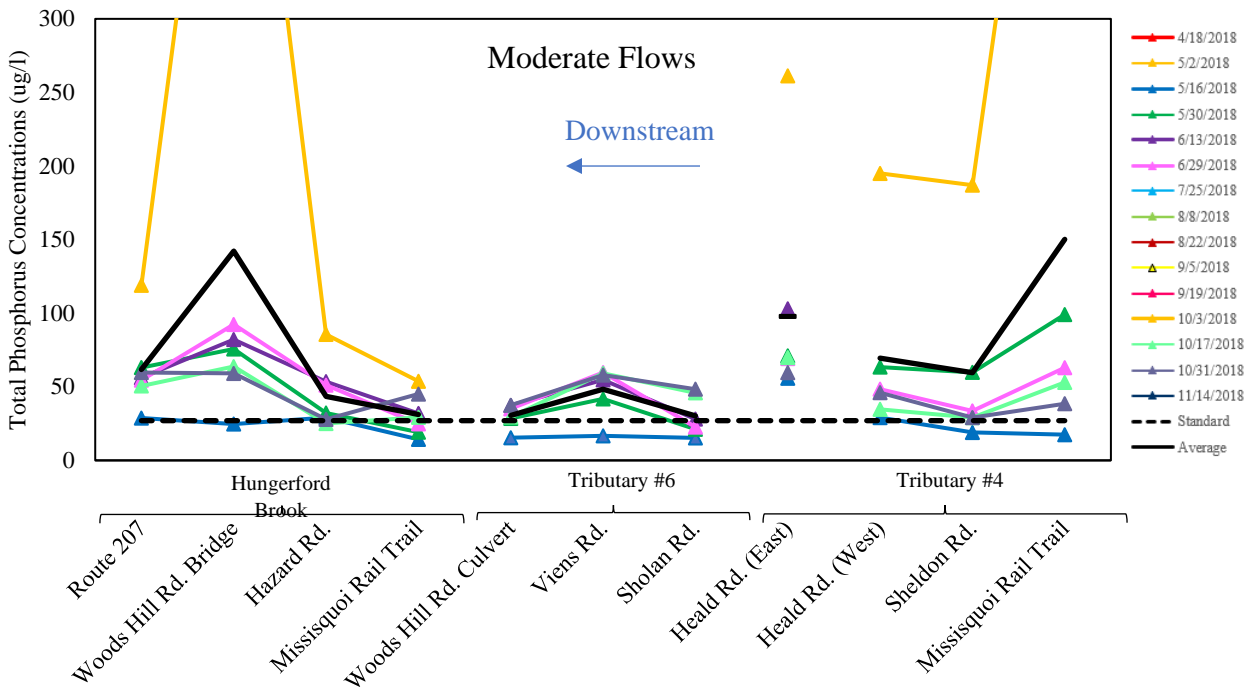
Table 4: Total phosphorus concentration results in micrograms per liter for the Hungerford Brook subwatershed sites for all sampling dates in 2018 and number of dates each site was sampled.



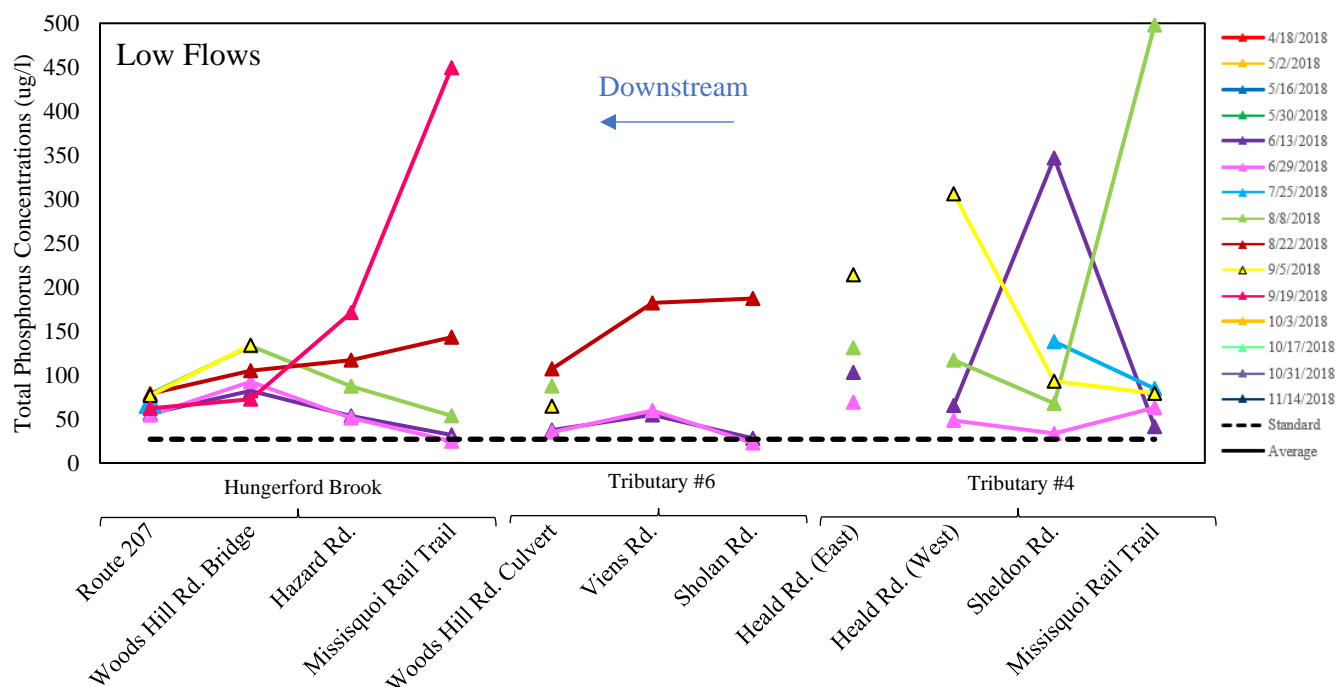
Graph 5: Box-plots displaying total phosphorus concentration results in micrograms per liter for the Hungerford Brook subwatershed sites. The black triangle represents the median, the upper and lower bounds of the grey box represent the third and first quartile, and the black lines represent the maximum and minimum values.



Graph 6: Total phosphorus concentration "profile" along the Hungerford Brook and tributaries #4 and #6 of the Hungerford Brook during high flow conditions. The black dotted line (27 ug/l TP) represents the 2016 Vermont Water Quality Standard for total phosphorus concentrations in warm-water, medium gradient streams.



Graph 7: Total phosphorus concentration "profile" along the Hungerford Brook and tributaries #4 and #6 of the Hungerford Brook during moderate and low flow conditions. The black dotted line (27 ug/l TP) represents the 2016 Vermont Water Quality Standard for total phosphorus concentrations in warm-water, medium gradient streams.



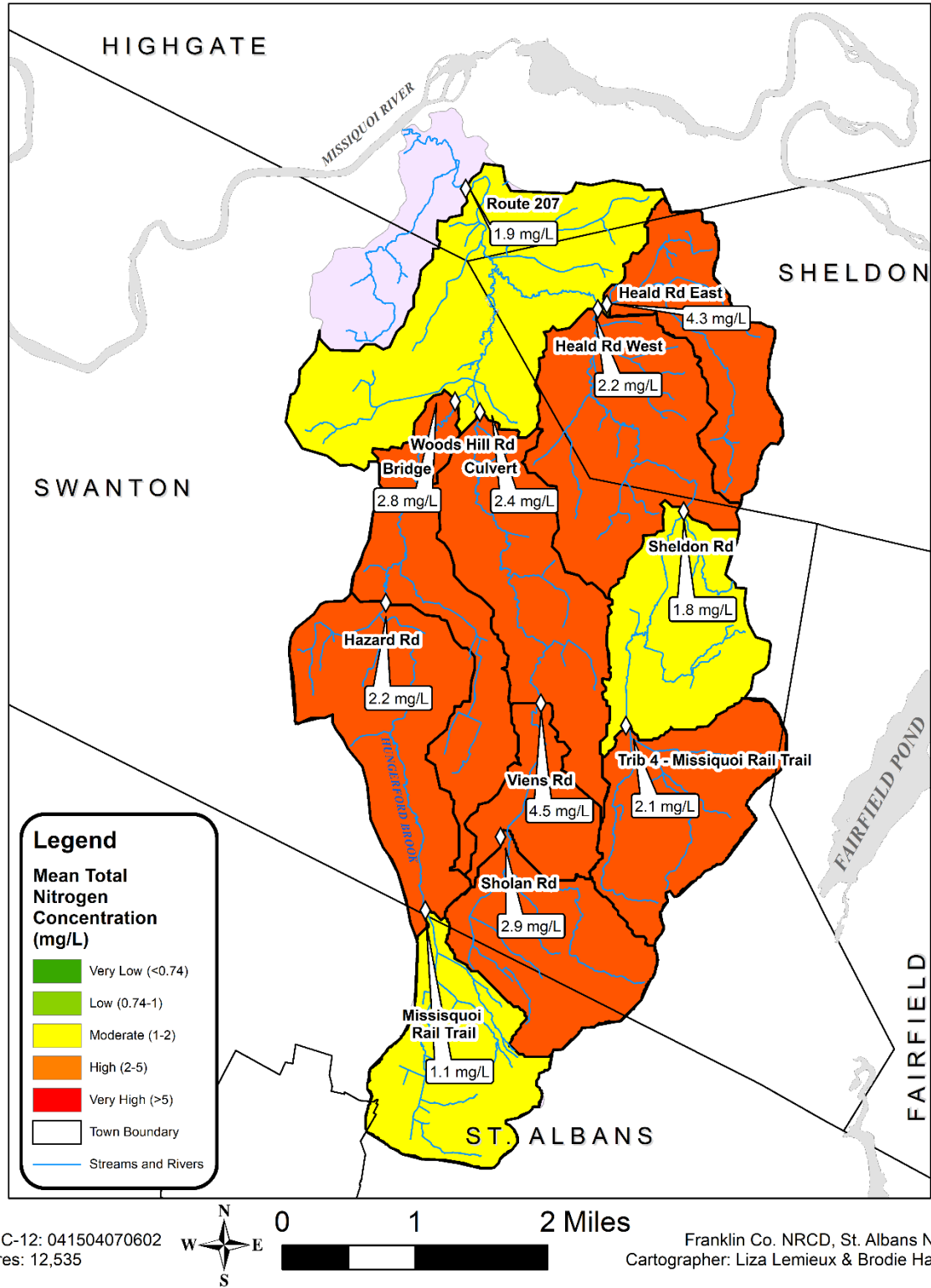
Graph 8: Total phosphorus concentration “profile” along the Hungerford Brook and tributaries #4 and #6 of the Hungerford Brook during low flow conditions. Data from June 13 along tributary #4 is excluded here due to a suspected beaver dam breach occurring upstream of the Sheldon Road site. Data from October 3 along tributary #6 is excluded here due to no flow conditions at Viens Road and Sholan Road. The black dotted line (27 ug/l TP) represents the 2016 Vermont Water Quality Standard for total phosphorus concentrations in warm-water, medium gradient streams.

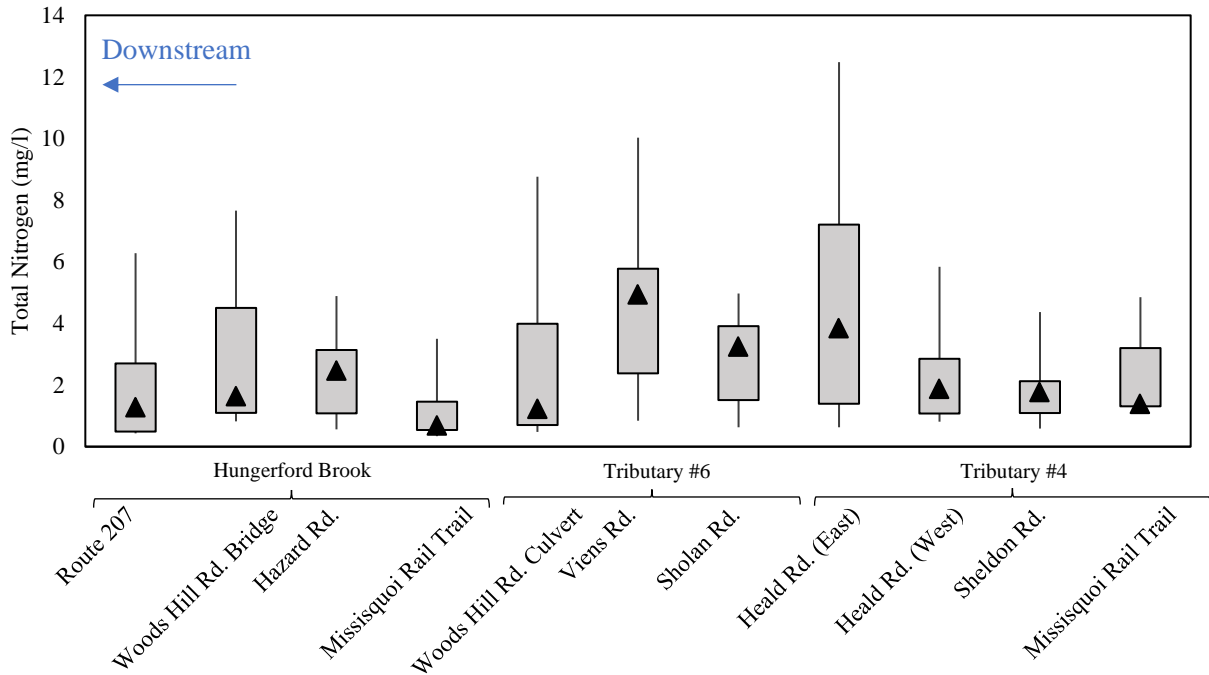
Like total phosphorus, mean total nitrogen concentrations were high to moderate throughout the Hungerford Brook subwatershed. Along the mainstem, total nitrogen concentrations typically increase between the Missisquoi Rail Trail site and Hazard Road, continue to increase between Hazard Road and Woods Hill Road Bridge, and decrease between Woods Hill Road Bridge and Route 207. Along tributary #4, total nitrogen concentrations were very high at the Heald Road (East) site and moderate to high at the other three sites along tributary #4, with more variable changes in concentrations upstream and downstream of each other. Along tributary #6, total nitrogen concentrations increased most dramatically between Sholan Road and Viens Road and decrease between Viens Road and Wood Hill Road Culvert.

Site Name	# of Dates Sampled	Median (mg/l TN)	Mean (mg/l TN)	Range (mg/l TN)
Hungerford Brook - Route 207	15	1.28	1.90	0.43-6.28
Hungerford Brook - Woods Hill Rd.	13	1.64	2.84	0.82-7.66
Hungerford Brook - Hazard Rd.	11	2.47	2.22	0.56-4.89
Hungerford Brook - Missisquoi Rail Trail	11	0.69	1.09	0.34-3.50
Hungerford Brook Tributary 6 - Woods Hill Rd.	15	1.23	2.37	0.48-8.76
Hungerford Brook Tributary 6 - Viens Rd.	9	4.94	4.50	0.84-10.03
Hungerford Brook Tributary 6 - Missisquoi Rail Trail	9	3.25	2.85	0.63-4.97
Hungerford Brook Tributary 4 - Heald Rd. (East)	14	3.85	4.28	0.63-12.48
Hungerford Brook Tributary 4 - Heald Rd. (West)	13	1.88	2.16	0.81-5.84
Hungerford Brook Tributary 4 - Sheldon Rd.	14	1.78	1.82	0.59-4.37
Hungerford Brook Tributary 4 - Missisquoi Rail Trail	15	1.39	2.05	1.13-4.85

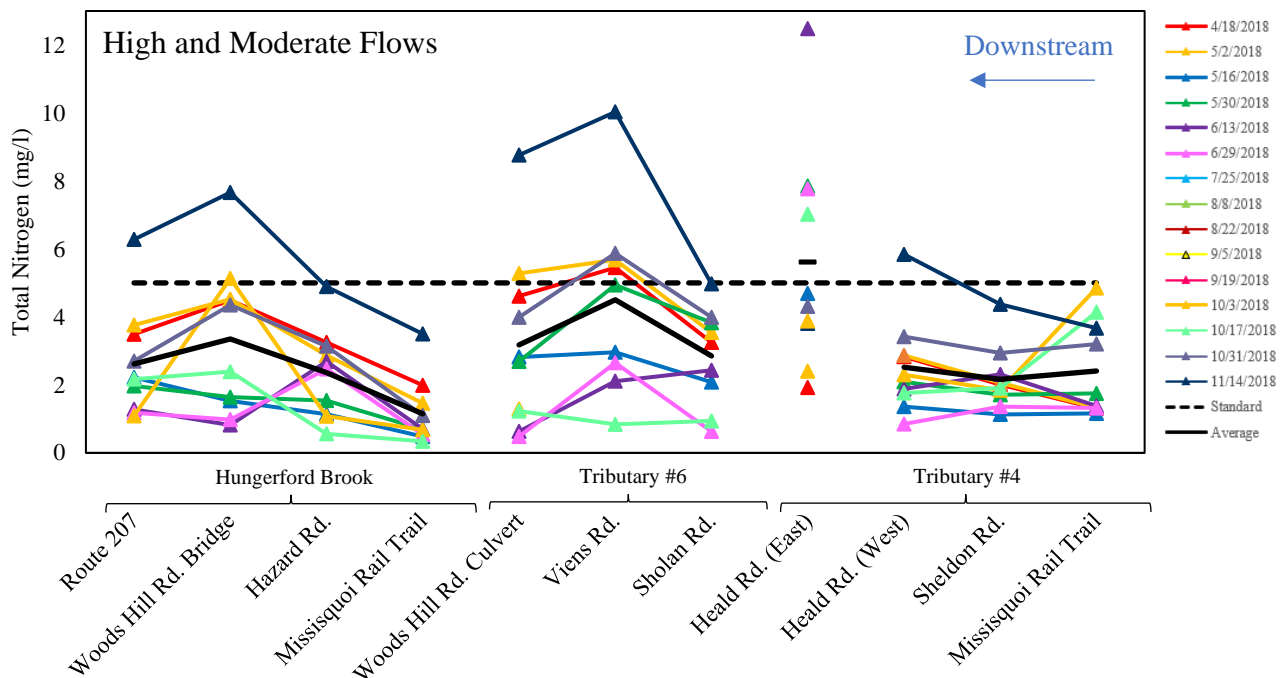
Table 5: Total nitrogen concentration results in micrograms per liter for the Hungerford Brook subwatershed sites for all sampling dates in 2018 and number of dates each site was sampled.

Hungerford Brook





Graph 9: Box-plots displaying total nitrogen concentration results in milligrams per liter for the Hungerford Brook subwatershed sites. The black triangle represents the median, the upper and lower bounds of the grey box represent the third and first quartile, and the black lines represent the maximum and minimum values.



Graph 10: Total nitrogen “profiles” along the Hungerford Brook and tributaries #4 and #6 of the Hungerford Brook during high and moderate flow conditions. The black dotted line (5 mg/l TN) represents the 2016 Vermont Water Quality Standard for total phosphorus concentrations in warm-water, medium gradient streams.

5.5 Black Creek

In 2018, the District collected total phosphorus and total nitrogen samples at thirteen sites in the Black Creek subwatersheds including seven sites along the mainstem of the Black Creek, two sites along the Fairfield River, and additional sites along the Dead Creek, Wanzer Brook, Fairfield River, Elm Brook, and Paige Brook. All seven sites along the Black Creek and the site along the Wanzer Brook were previously monitored by the MRBA. The sites along the Dead Creek and Fairfield River are direct recommendations from a previous report on water quality data in the Black Creek watershed (Gerhardt 2018).

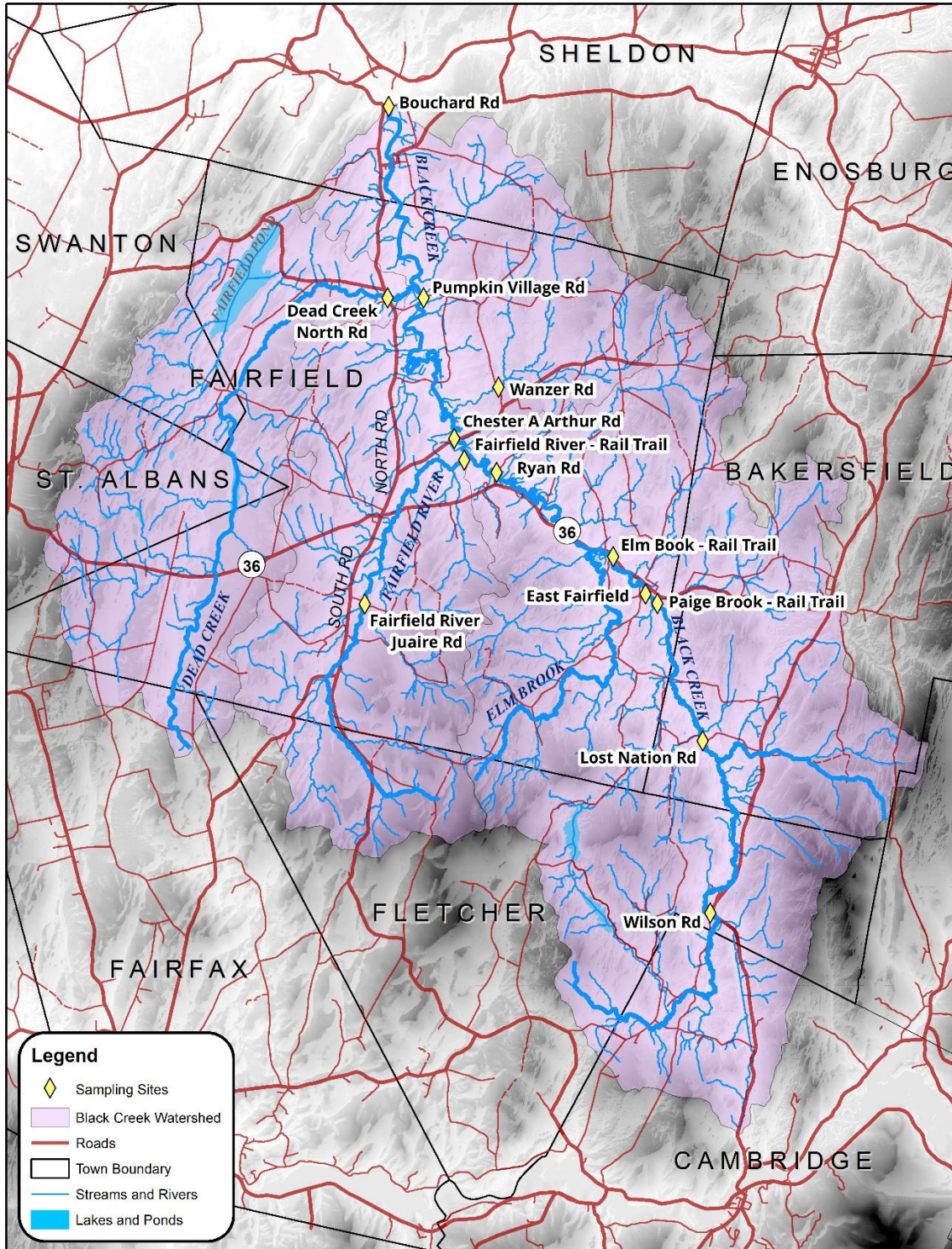


Picture 4: Taken September 5, 2018.
Upstream of the Fairfield River – Rail Trail
site during low flow conditions.



Picture 5: Taken September 19, 2018.
Upstream of the Fairfield River – Rail Trail
site during no flow conditions.

Black Creek



HUC-12: 04504070601
Acres: 25,844



0 1.5 3 Miles

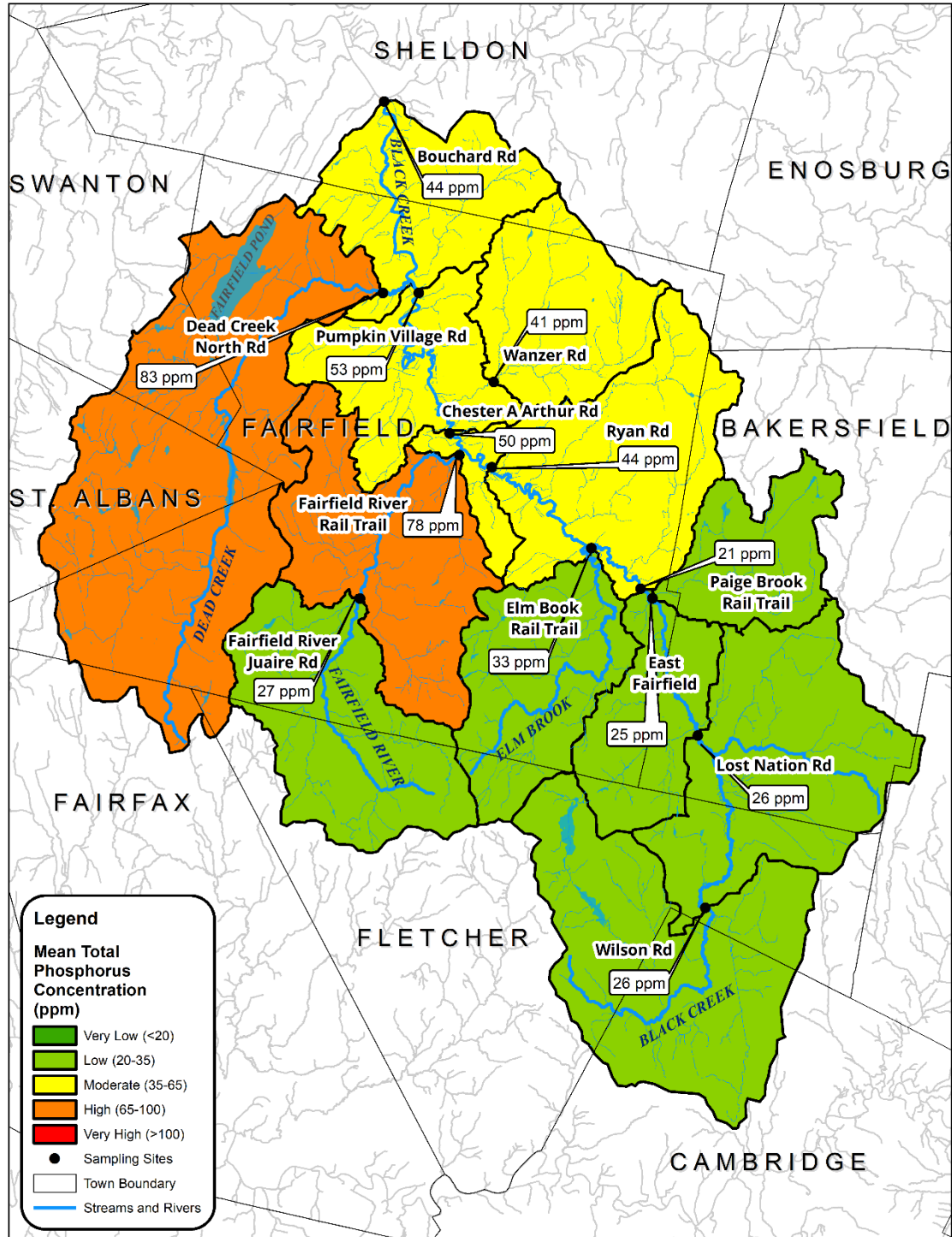
Franklin Co. NRCD, St. Albans NRCS
Cartographer: Liza Lemieux & Brodie Haenke

In 2018, mean total phosphorus concentrations along the mainstem of the Black Creek were low to moderate, with concentrations dramatically increasing between the Rail Trail and Ryan Road sites and continuing to moderately increase between each site until the final reach between Pumpkin Village and Bouchard Road where concentrations slightly decrease. In tributaries to the Black Creek, mean total phosphorus concentrations were highest at the Dead Creek – North Road site and the Fairfield River – Rail Trail site. Mean total phosphorus concentrations were moderate in the Wanzer Brook and Elm Brook, and low in the Paige Brook. These results suggest there are significant sources of phosphorus between the Rail Trail and Ryan Road sites and Ryan Road and Chester A. Arthur Road sites along the Black Creek. The dramatic increase in phosphorus between Juair Road and Rail Trail sites along the Fairfield River during the dry summer months may be the result of a localized impediment to stream flow. District staff observed that a stream crossing immediately downstream of the monitoring site partially dams the Fairfield River during low flow conditions, causing the stream to become stagnant, anoxic, and potentially leading to the release of phosphorus from the streambed to the water column. Only moderate increases in total phosphorus concentrations were observed between Juair Road and the Rail Trail sites along the Fairfield River during moderate and high flow conditions.

Site Name	# of Dates Sampled	Median (ug/l TP)	Mean (ug/l TP)	Range (ug/l TP)
Black Creek - Bouchard Rd.	15	41.1	44.3	22.5-78
Black Creek - Pumpkin Village Rd.	15	52.1	52.8	22.9-88.7
Black Creek - Chester A. Arthur Rd.	15	48.1	49.5	16.1-116
Black Creek - Ryan Rd.	15	39.1	44.2	14.8-132
Black Creek - Rail Trail	15	22.9	24.8	12.2-63.5
Black Creek - Lost Nation Rd.	15	25.2	25.5	12.3-62.1
Black Creek - Wilson Rd.	15	25	25.8	10.2-76.3
Dead Creek - North Rd.	15	42.1	83.2	17-624
Wanzer Brook - Wanzer Rd.	10	32.5	41.3	13.3-110
Fairfield River - Rail Trail	14	37	77.6	15.3-252
Fairfield River - Juair Rd.	13	22.5	27.2	11.8-55.1
Elm Brook - Rail Trail	15	29.7	33.3	11.0-83.5
Paige Brook - Rail Trail	15	18.2	20.6	13-36

Table 6: Total phosphorus concentration results in micrograms per liter for the Black Creek subwatershed sites for all sampling dates in 2018 and number of dates each site was sampled.

Black Creek Total Phosphorus



Dead Creek: 041504070502

Black Creek: 041504070503

Headwaters Black Creek: 041504070501

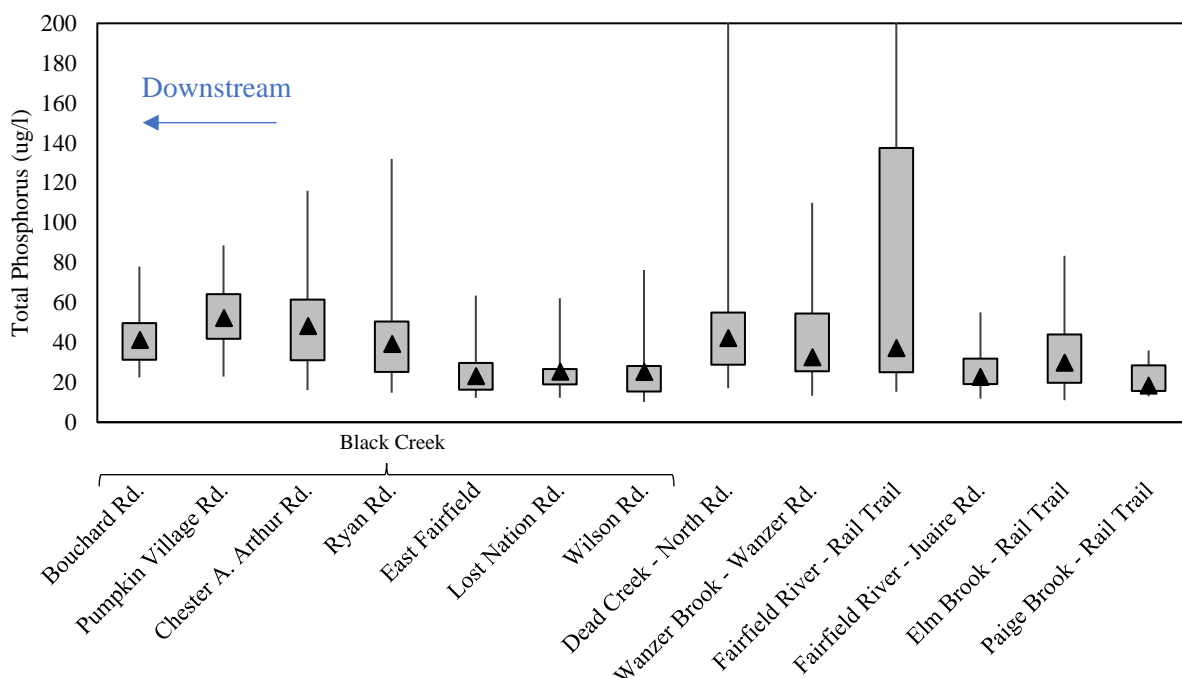


0 1 2 Miles

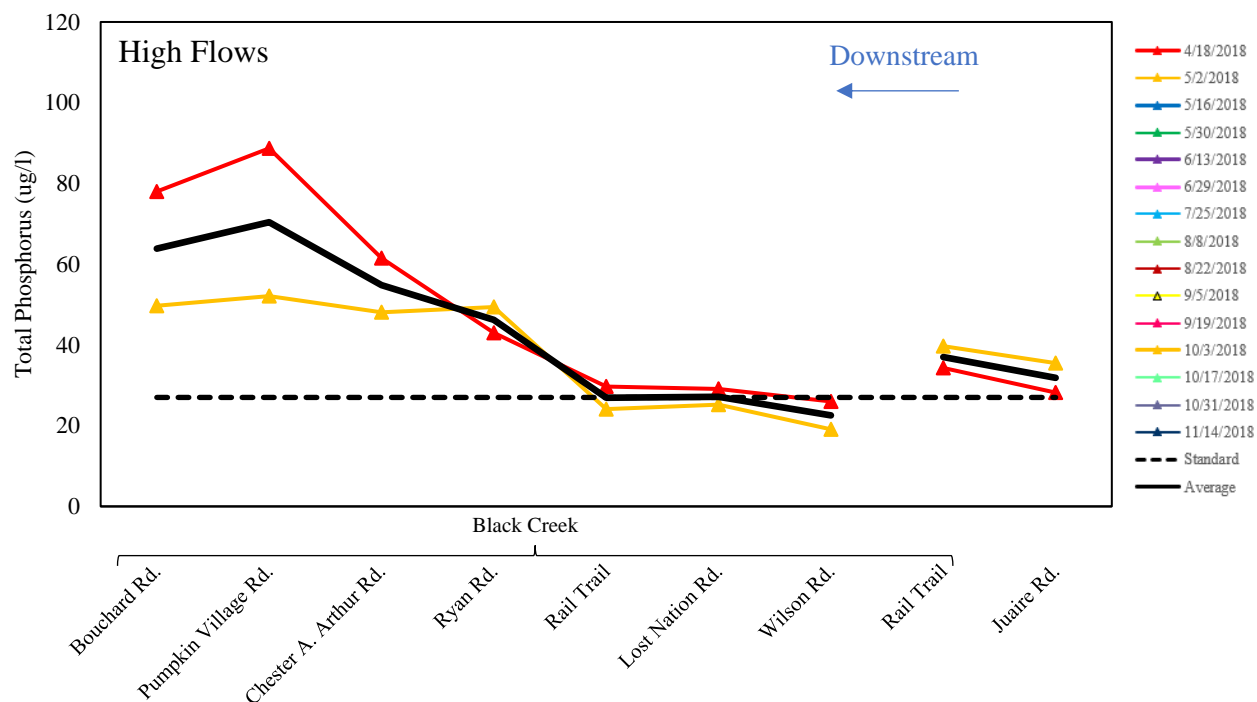


Franklin Co. NRCD, St. Albans NRCS

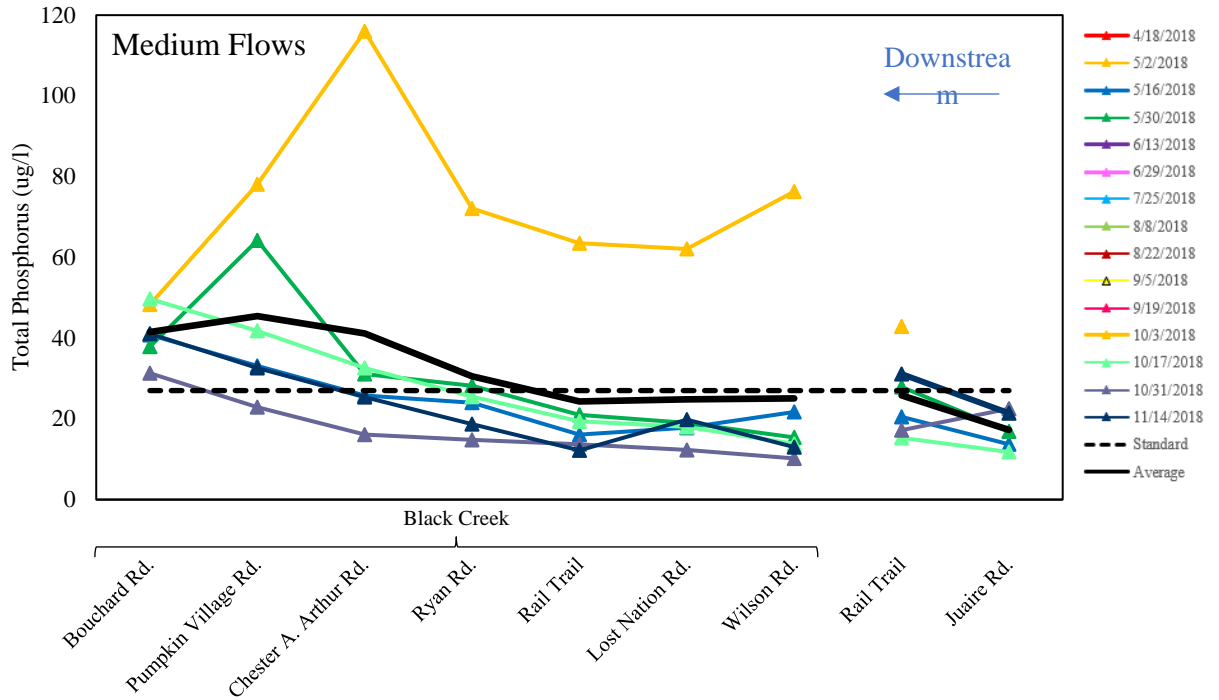
Cartographer: Liza Lemieux & Brodie Haenke



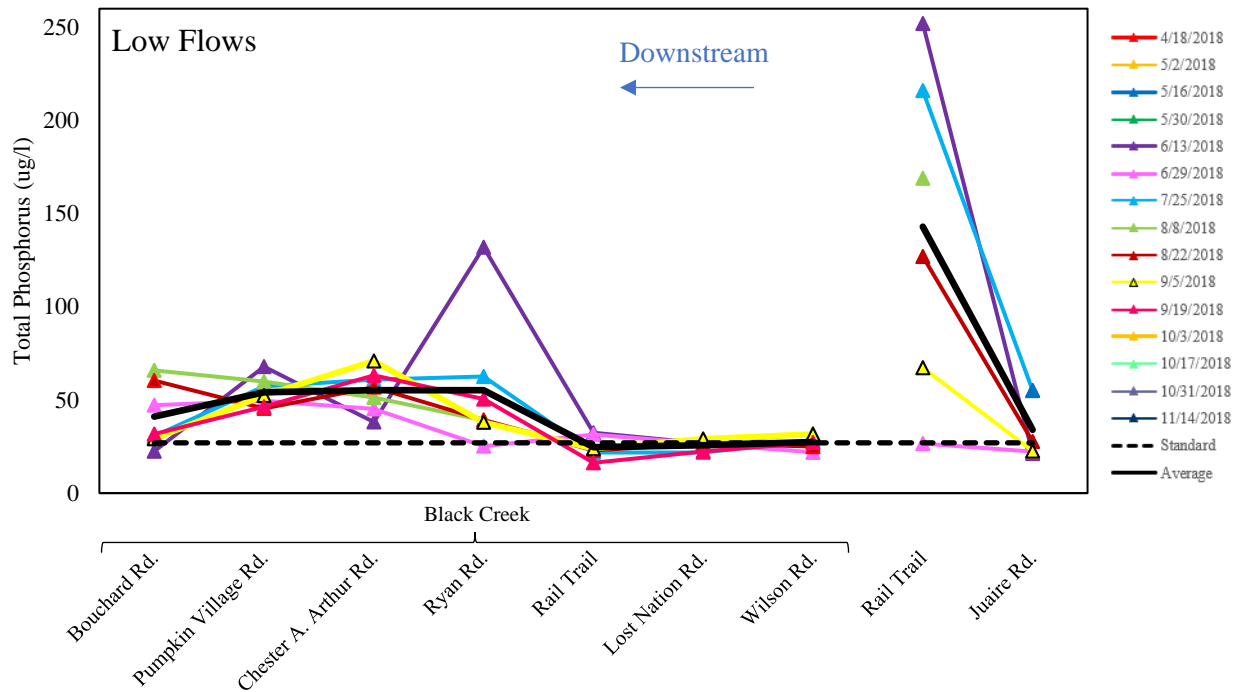
Graph 11: Box-plots displaying total phosphorus concentration results in micrograms per liter for the Black Creek subwatershed sites. The black triangle represents the median, the upper and lower bounds of the grey box represent the third and first quartile, and the black lines represent the maximum and minimum values.



Graph 12: Total phosphorus concentration "profile" along the Black Creek and Fairfield River during high flow conditions. The black dotted line (27 ug/l TP) represents the 2016 Vermont Water Quality Standard for total phosphorus concentrations in warm-water, medium gradient streams.



Graph 13: Total phosphorus concentration "profile" along the Black Creek and Fairfield River moderate flow conditions. The black dotted line (27 ug/l TP) represents the 2016 Vermont Water Quality Standard for total phosphorus concentrations in warm-water, medium gradient streams.



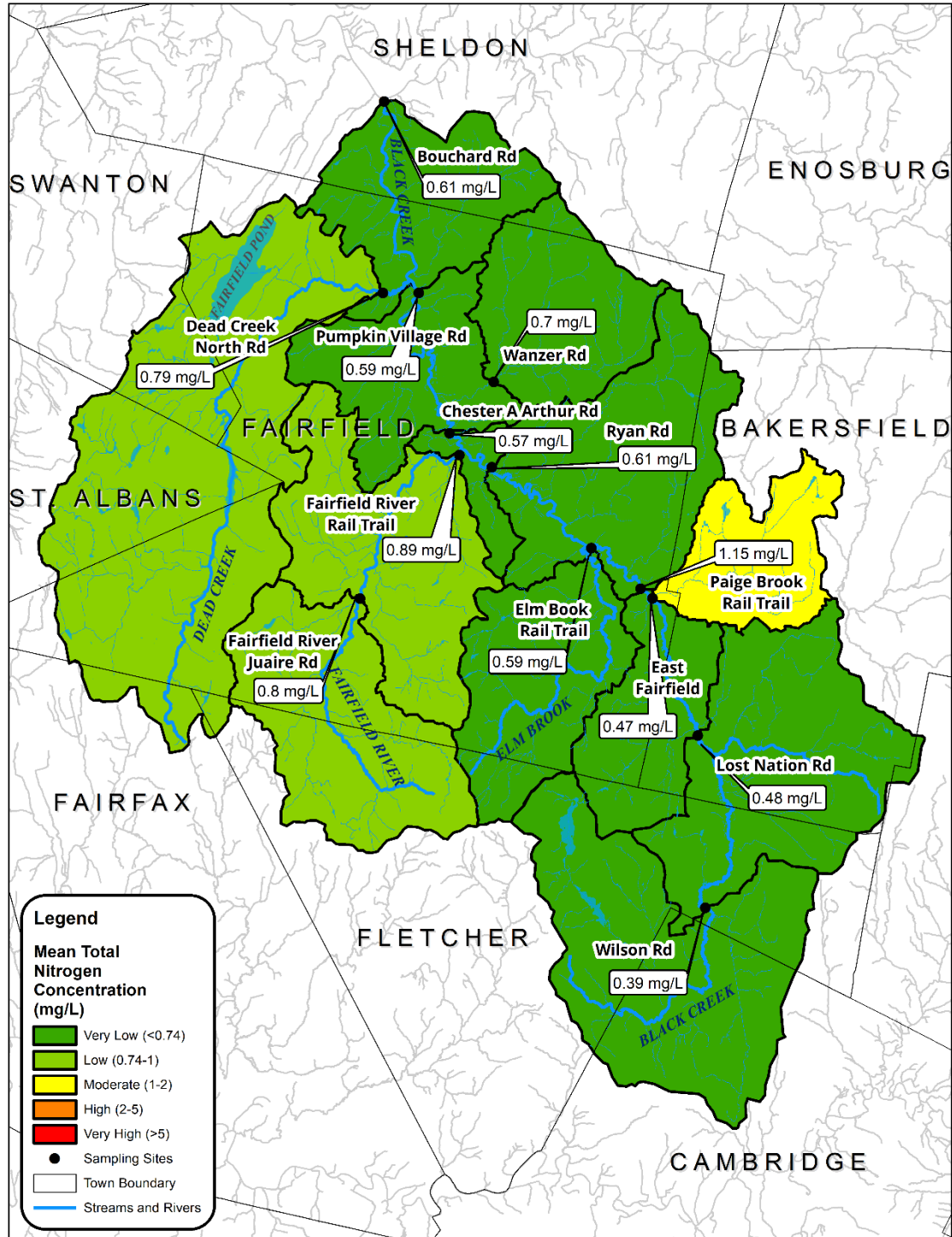
Graph 14: Total phosphorus concentration "profile" along the Black Creek and Fairfield River during low flow conditions. The black dotted line (27 ug/l TP) represents the 2016 Vermont Water Quality Standard for total phosphorus concentrations in warm-water, medium gradient streams.

As stated in previous reports on water quality conditions in the Black Creek subwatershed, total nitrogen concentrations are relatively low along the Black Creek and in its tributaries. In contrast to the total phosphorus results, mean total nitrogen concentrations were highest in the Paige Brook in comparison to all other monitoring sites in the Black Creek subwatersheds, although this value was still well below the 2016 Vermont Water Quality Standards.

Site Name	# of Dates Sampled	Median (mg/l TN)	Mean (mg/l TN)	Range (mg/l TN)
Black Creek - Bouchard Rd.	15	0.57	0.61	0.41-0.90
Black Creek - Pumpkin Village Rd.	15	0.54	0.59	0.39-1.07
Black Creek - Chester A. Arthur Rd.	15	0.5	0.57	0.39-1.08
Black Creek - Ryan Rd.	15	0.55	0.61	0.43-1.04
Black Creek - Rail Trail	15	0.38	0.47	0.29-1.55
Black Creek - Lost Nation Rd.	15	0.42	0.48	0.29-1.29
Black Creek - Wilson Rd.	15	0.33	0.39	0.24-1.22
Dead Creek - North Rd.	15	0.5	0.79	0.30-4.81
Wanzer Brook - Wanzer Rd.	10	0.63	0.70	0.29-1.17
Fairfield River - Rail Trail	14	0.63	0.89	0.30-2.50
Fairfield River - Juair Rd.	13	0.69	0.80	0.18-1.83
Elm Brook - Rail Trail	15	0.58	0.59	0.38-0.82
Paige Brook - Rail Trail	15	1.27	1.15	0.53-1.48

Table 7: Total nitrogen concentration results in micrograms per liter for the Black Creek subwatershed sites for all sampling dates in 2018 and number of dates each site was sampled.

Black Creek Total Nitrogen

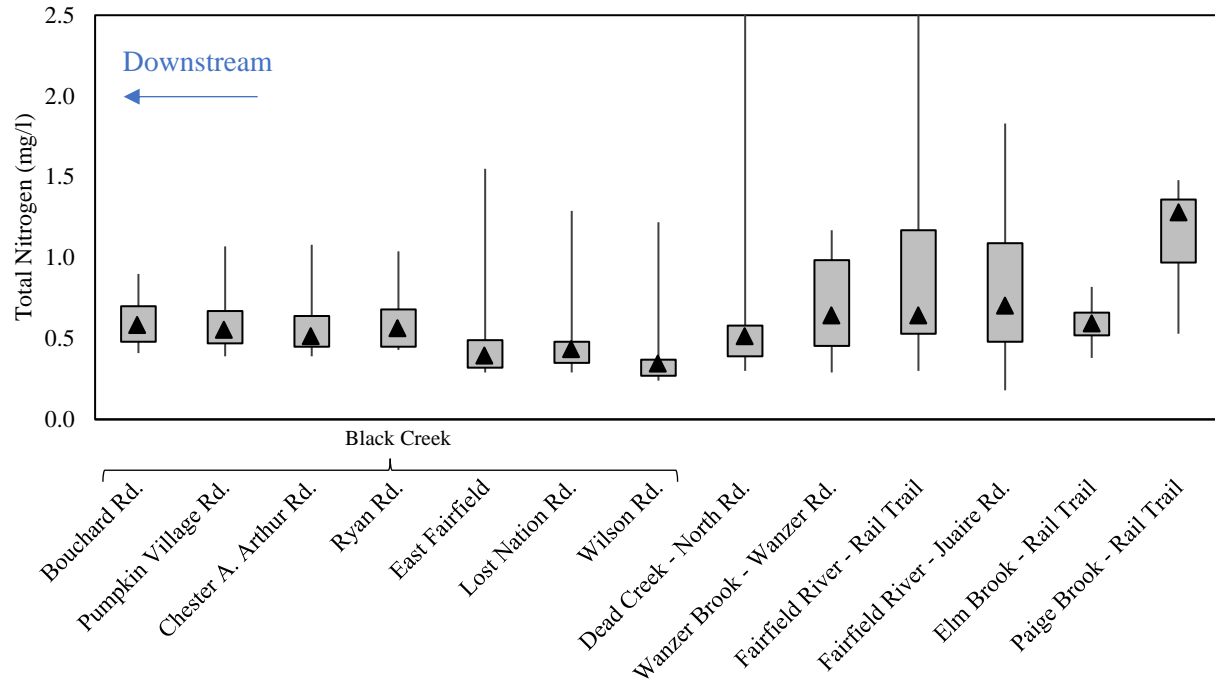


Dead Creek: 041504070502
 Black Creek: 041504070503
 Headwaters Black Creek: 041504070501

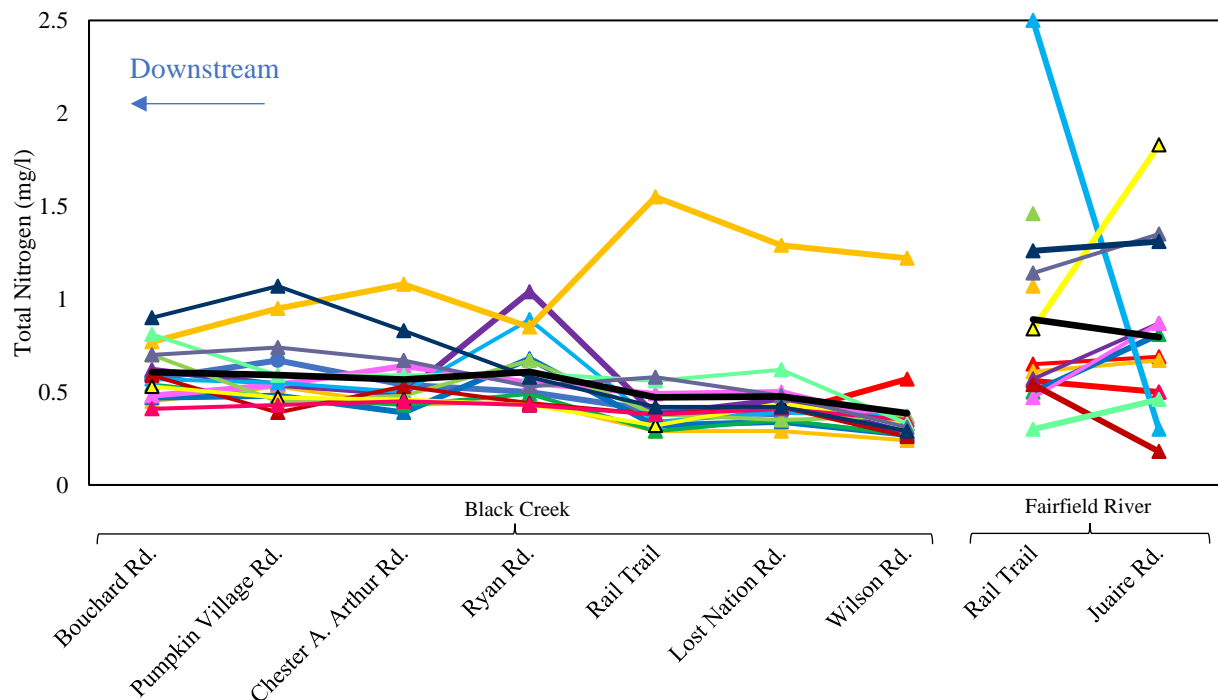


0 1 2 Miles

Franklin Co. NRCD, St. Albans NRCS
 Cartographer: Liza Lemieux & Brodie Haenke



Graph 15: Box-plots displaying total nitrogen concentration results in milligrams per liter for the Black Creek subwatershed sites. The black triangle represents the median, the upper and lower bounds of the grey box represent the third and first quartile, and the black lines represent the maximum and minimum values.



Graph 16: Total nitrogen “profiles” along the Black Creek and the Fairfield River during all flow conditions. The black dotted line (5 mg/l TN) represents the 2016 Vermont Water Quality Standard for total phosphorus concentrations in warm-water, medium gradient streams.

6.0 Conclusions

This report summarizes the water quality data collected by the Franklin County Conservation District in 2018 as part of the Vermont DEC's LaRosa Partnership Program. The goal of this program is to (1) characterize water quality conditions in the Hungerford Brook and Black Creek watersheds, (2) pinpoint significant sources of phosphorus and nitrogen loading within these watersheds, (3) identify areas of focus for conservation projects and other efforts to improve water quality, (4) make recommendations for future water quality monitoring efforts.

Adding additional sites upstream of previously monitored sites and a lengthier sampling season greatly improved the clarity of our water quality results. Along the Hungerford Brook mainstem, total phosphorus concentrations increased consistently and most dramatically between Hazard Road and Woods Hill Road, suggesting there are sources of available phosphorus between this stream reach. Total phosphorus concentrations were high at every site along tributary #4 with the highest mean total phosphorus concentrations at the upstream most site along the Missisquoi Rail Trail followed by the Heald Road (East) site. Along tributary #6, total phosphorus concentration increases were greatest between the Sholan Road site and Viens Road.

Along the Black Creek, total phosphorus concentrations increased most consistently and dramatically between the East Fairfield and Ryan Road. This stream reach is characterized by significant modifications to the river channel to accommodate for the historic path of the railroad (now rail trail) and by an abundance of adjacent annual crop fields. Many of the tributaries to the Black Creek have relatively low total phosphorus concentrations and very low total nitrogen concentrations. Exceptions to this include the Fairfield River during low flow conditions due to some localized sediment inputs from a stream crossing damming of the Fairfield River.

Future monitoring efforts should focus on sampling during a greater range of flow conditions as most sample collection dates have occurred during moderate and low flow conditions. This could be achieved by sampling at a greater range of seasons or by sampling more selectively during high flow events. The District also recommends that additional sites be added along the major tributaries to the Black Creek between Ryan Road and East Fairfield where total phosphorus concentrations increase most consistently and dramatically.

Additional sites could be added upstream of the Missisquoi Rail Trail site along tributary #4 of the Hungerford Brook to better pin point potential sources of sediment and nutrient loading. Additional sites could be added upstream of the Heald Road (East) site to better pin point the high total phosphorus concentrations and very high total nitrogen concentrations. An additional site could be added between Woods Hill Road and Hazard Road along the mainstem of the Hungerford Brook to better pinpoint sources of phosphorus, nitrogen, and sediment loading.

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Appendix

Parameter	Number of Samples Anticipated	Number of Valid Samples Collected & Analyzed	Percent Complete
Total phosphorus (persulfate digestion)	412	327	79%
Total nitrogen (persulfate digestion)	412	327	79%

Sample Number	Date	Location	TP	Mean	RPD	TN	Mean	RPD
180877-25	5/31/2018	Paige Brook - Rail Trail	19.8	17.75	23%	0.69	0.935	52%
180877-24			15.7			1.18		
181061-25	6/13/2018	Hazard Rd.	50.7	52.1	5%	2.72	2.705	1%
181061-03			53.5			2.69		
181206-25	6/29/2018	Hazard Rd.	47.3	49.25	8%	2.41	2.44	2%
181206-03			51.2			2.47		
181825-25	9/5/2018	Sheldon Rd.	83.3	88.2	11%	0.66	0.625	11%
181825-10			93.1			0.59		
181965-16	9/19/2018	Bouchard Rd.	32.2	31.95	2%	0.44	0.425	7%
181965-05			31.7			0.41		
182095-27	10/3/2018	Wilson Rd.	107	91.65	33%	1.32	1.27	8%
182095-18			76.3			1.22		
182095-25	10/3/2018	Bouchard Rd.	46.9	47.6	3%	0.76	0.765	1%
182095-12			48.3			0.77		
182181-27	10/17/2018	Lost Nation Rd.	25.8	21.9	36%	0.61	0.615	2%
182181-17			18			0.62		
182181-25	10/17/2018	Pumpkin Village Rd.	41.4	41.6	1%	0.6	0.595	2%
182181-13			41.8			0.59		
182291-27	10/31/2018	Lost Nation Rd.	12.8	12.55	4%	0.45	0.465	6%
182291-17			12.3			0.48		
182291-25	10/31/2018	Pumpkin Village Rd.	23.9	23.4	4%	0.73	0.735	1%
182291-13			22.9			0.74		
182291-26	10/31/2018	Route 207	60.4	60.05	1%	2.63	2.665	3%
182291-01			59.7			2.7		
182361-27	11/14/2018	Lost Nation Rd.	16.1	17.95	21%	0.41	0.415	2%
182361-17			19.8			0.42		
182361-25	11/14/2018	Pumpkin Village Rd.	32.8	32.7	1%	1.06	1.065	1%
182361-13			32.6			1.07		
			Mean TP RPD		11%	Mean TN RPD		7%